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Albuquerque, NM

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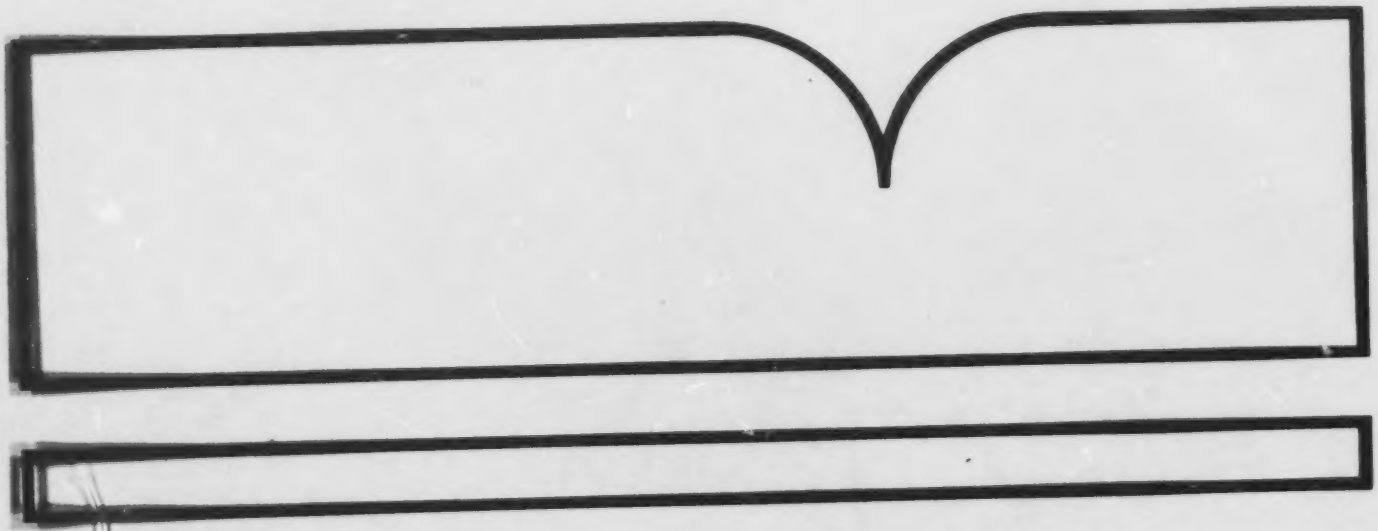

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A Review of Standards of Performance for New Stationary Sources - Secondary Lead Smelters

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This report reviews the current Standards of Performance for New Stationary Sources: Subpart L - Secondary Lead Smelters. It includes a summary of the current standards, the status of applicable control technology, and the ability of secondary lead smelters to meet the current standards. Compliance test results are analyzed and a recommendation made to retain the current standard. Information used in this report is based upon data available as of November 1978.

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1.0 EXECUTIVE SUMMARY

This report reviews current New Source Performance Standards (NSPS) for secondary lead smelters and analyzes possible revisions. It provides background information to be used by the U.S. Environmental Protection Agency in assessing the need for possible revision of the NSPS.

1.1 Scope of Standards

Currently the NSPS for secondary lead smelters applies to particulate emissions and opacity. Particulate levels are set at 50 mg/dscm* (0.022 gr/dscf**) for blast and reverberatory furnaces. Opacity of emissions from these furnaces may be no greater than 20 percent. Pot furnaces with capacity exceeding 550 tons are subject to standards for opacity only, which is set at a maximum of 10 percent.

1.2 Overview of Secondary Lead Industry

Secondary lead produced by smelting of scrap accounts for roughly half of all lead produced in the U.S. After a record output of over 626,000 tons in 1976, secondary lead output declined in 1977 to between 588,000 and 600,000 tons (Bureau of Mines, 1978). Used vehicular batteries typically account for some 60 percent of all lead scrap recycled annually at secondary smelters. Storage batteries for vehicles and other uses accounted for more than half of the total U.S. demand for lead (primary and secondary combined) in 1976. The

*Milligrams per dry standard cubic meter.
**Grains per dry standard cubic foot.

transportation sector is expected to consume a larger share of total output by the year 2000. Major consumption of lead for construction and electrical purposes, paints and pigments is also expected to continue. Attrition of the tetraethyl lead market for gasoline additives and a continuing shift to other materials for such purposes as pipes, caulking, cable sheathing and interior paints are expected to reduce the rate of, but not prevent, increase in lead demand over the next 20 to 25 years. On the average, output of secondary lead has increased by about 1.4 percent annually since 1955.

The secondary lead industry is characterized by a high degree of concentration in that a few companies dominate the market. The trend is towards fewer and larger plants. Total number of smelters decreased from 160 in 1967 to about 115 in 1975. Overall, the average annual output per smelter is in the range of 5700 to 6000 tons. Geographically, the industry is somewhat dispersed; secondary lead smelters are located in all of the 10 EPA regions.

Best estimates are that on the average two new plants and from one to two modified smelters will become subject to NSPS each year (EPA, 1973; Bureau of Mines, 1978). EPA projection of a typical secondary smelter with a 50 ton/day capacity and a flow rate of 15,000 scfm has been used as the basis for many of the calculations in this report.

1.3 Control Technology

1.3.1 Source of Emissions

Operating blast and reverberatory furnaces emit particulate matter from the stacks. EPA has estimated average rates of uncontrolled particulates emitted to be about 147 lb/ton of metal charged to a reverberatory furnace and about 193 lb/ton for a blast furnace. On the basis of about 70 percent recovery of metal, these rates exceed 200 lb of particulates/ton of lead product. Average emission rates of SO_2 per ton of lead product are estimated to be about 76 lb and 114 lb for blast and reverberatory furnaces, respectively (EPA, 1975). Pot furnaces, which are used in secondary smelters only to remelt and purify or alloy the product of a blast or reverberatory furnace, emit particulates and SO_2 at a rate which was indicated as negligible by EPA (1975). The particulate emissions from secondary lead furnaces have a lead content estimated at 23 percent (EPA, 1977). Their capture is, therefore, important for environmental protection and is also advantageous to plant operation because the fines recovered can be recycled in further lead processing.

1.3.2 Types of Control

For collection of particulates, fabric filters and high-energy wet collectors of the variable-throat (venturi) type are effective in enabling secondary lead smelters to meet the NSPS. A baghouse or venturi scrubber may be employed alone or in combination with auxiliary devices in secondary lead furnaces.

Efficiencies well above 99 percent are typically required of control systems to meet particulate standards imposed on secondary lead smelters. Inlet particulate loadings from about 3 up to 12 gr/dscf of gas may be presented to collectors from a representative furnace requiring efficiencies of over 99.5 percent.

1.3.3 Results of Controls

The reduction in particulate emissions from establishment of the NSPS is estimated to be about 1000 tons each year from those plants newly subject to the standards (i.e., plants built, modified or reconstructed during that year). While this is a small reduction in comparison with the total estimated particulate emissions for the U.S. of 16 million tons (in the year 1976), the lead content of the particles makes their capture environmentally important. Since future plants may be twice the size of the present average, a reduction in particulate emissions of twice the above value may occur in the next few years. Possible adverse environmental effects and resource consumption have been relatively small. EPA (1973) estimated negligible solid waste disposal requirements because of recycling of captured particulate matter. Incremental energy requirements for fabric filter controls are insignificant because of very nominal pressure drop (4 inches of water gauge) through the baghouse. The very high pressure drops (30 to 100 inches water gauge) required with high-energy scrubbers increase horsepower requirements and result in additional fuel consumption estimated as the equivalent of about 1000 barrels of oil per plant annually. The

total additional energy consumption each year would depend on the number and production rate of new and modified plants coming in line which used high-energy venturi scrubbers. Since no more than four new and modified plants are estimated in any one year, the increment would represent much less than 1 percent of the average daily import to the U.S. of more than 7 million barrels for the year 1976 (Bureau of Mines, 1976).

1.3.4 Costs of Controls

Costs of control have been high to operators of secondary lead smelters that come under NSPS. EPA has estimated costs for 50 ton/day model blast and reverberatory furnaces equipped with baghouses (fabric filters) and with venturi scrubbers. Capital costs for control of such a blast furnance using fabric filters are estimated (EPA, 1977) to be on the order of $1.24 million and about $470,000 for a reverberatory furnace (in 1976 dollars). These costs have also been estimated on an annualized basis, representing amortization of capital outlays and expenditures for operation and maintenance. In terms of the value of the lead product, yearly control costs are estimated to be on an overall average about $78/ton for a blast furnace and $9/ton for a reverberatory furnance. These amounts represent, respectively, about 14.6 and slightly less than 2 percent of the average value of the lead product (based on an average price per ton of lead of about $535). Venturi scrubbers are estimated to involve capital costs of about $895,000 for blast furnaces and $669,000 for reverberatory furnaces (EPA, 1978). The resulting

annualized costs represent, respectively, about $33 and $22 per ton of lead product, or about 6 and 4 percent of product value.

1.4 Test Results

Information on only four tests of secondary lead smelters was available to the study. In these results for blast, reverberatory and pot furnaces, particulate emissions were 0.0135, 0.015 and 0.0013 gr/dscf, respectively, compared with the current NSPS level of 0.022 gr/dscf. Opacity readings were less than the maximum allowable percentage. This sample is too small to be considered as adding anything to the results reported by EPA (1973) at the time of preparing the NSPS.

1.5 Industry Trends

The concentration of the secondary lead production in the hands of a few large companies which dominate the market is expected to continue. Despite shifts in demand patterns and attrition of the major tetraethyl lead market, consumption of all lead (primary and secondary) is expected to grow at an average rate of nearly 2 percent/year from 1976 to 2000.

A trend in the lead industry, both secondary and primary, which has been under way since at least the mid-fifties has been a decrease in the real price of the metal product. In other words, although the sales price of lead per ton has increased, in terms of constant dollars (i.e., relative to overall inflation), the value has declined. Despite occasional oscillations, the price has decreased about 27

percent since 1954 (Bureau of Mines, 1977). Thus, the industry is faced simultaneously with decreasing net income margins and with the need for expensive capital outlays for control equipment.

1.6 Possible Changes: Analysis, Conclusions and Recommendations

1.6.1 Current NSPS

Available data indicate that no change is warranted in current NSPS for particulates and opacity from secondary lead smelters. Additional data are needed to investigate the:

- Extent of fugitive emissions from secondary lead plants subject to NSPS control.
- Present state of control technology applicable to both fugitive and stack emissions. In regard to the latter, the type of control equipment seen as reflecting best current technology does not seem to have changed since the NSPS were promulgated. However, more information on capabilities under a range of representative operating parameters of both the devices themselves and the furnaces is needed as a basis for considering whether the level of control technology has significantly advanced.

1.6.2 Standards for Lead Emissions

No NSPS which would set levels specifically for lead emissions from secondary smelters are warranted at this time because best technological control systems for particulates also represent BACT for lead which is required by current standards for particulates. Available evidence indicates that control systems trap at least as high a percentage of lead-bearing particles as were emitted by the furnace (23 percent) and, hence, that no useful purpose would be served by developing new standards for lead emissions which would be redundant to those already promulgated for particulate control. Furthermore,

two standards applicable to the same particulate control system would cause potential administrative and enforcement difficulties.

However, the information on lead emissions from secondary lead smelters is not totally comprehensive so that it is not now possible to eliminate all doubt on the issue. One recent study suggested a higher percentage of lead in stack emissions. To confirm the conclusions which are implied by currently available data, a comprehensive analysis of the matter is warranted. It is recommended that additional data should be collected under field and laboratory conditions and analyzed to determine the disposition of the lead-bearing particles of various sizes emitted from the furnace. A materials balance should resolve the issue, based on comparison of the size distribution of lead particles from baghouse catches with those emitted from the furnace (inlet loading to the control system) and those trapped in the output from the control system.

1.6.3 Investigation of Standards for SO_2

Total SO_2 emissions from all secondary lead smelters are not excessive on the present uncontrolled basis when compared with the overall output of other industries. Nor are the ground-level concentrations of SO_2 at the point of maximum concentration predicted to occur from secondary smelters of typical size under average meteorological conditions high, relative to ambient standards. However, the rates of uncontrolled emissions of SO_2 per ton of lead product from secondary smelters seem somewhat high per ton of product when compared with those for other industries and with rates for sources

controlled under NSPS. Emission rates of SO_2 per ton of secondary lead product are on the average about twice those from regenerative furnaces used in filter glass manufacture and they compare with uncontrolled rates for sulfuric acid plants on a per ton of product basis.

It appears that the BACT could potentially reduce SO_2 emissions from secondary lead smelters by about 80 to 90 percent of uncontrolled rates. Such a reduction would represent technology transfer from control methods used elsewhere, particularly in control of large fossil fuel fired boilers in utilities and other industrial plants. Limited information available from manufacturers of control equipment indicates that the most efficient and economic means consist of a wet collector system that uses an alkaline reagent to neutralize sulfur oxides in the stack gas while simultaneously scrubbing out particulates.

Although the potential for technology transfer looks promising, the economic aspects require a much more detailed analysis than is possible from information currently available. Based on available data, best estimates currently possible of the capital costs for a combined system are from 10 to 20 percent higher than costs for a venturi scrubber designed to control particulate emissions only (although an increase in costs by as much as one-third cannot be ruled out). On an annualized basis the additional increment would appear to represent less than 5 percent of the average value of a ton of lead product and is probably in the range of 2 to 3 percent.

Annualized cost estimates per ton of SO_2 removed are about $115 for a reverberatory furnace and $235 for a blast furnace.

The ability of the secondary lead industry to afford these increased costs is also an issue that warrants close investigation. At present, the potential impact on the industry is very difficult to assess because of the proprietary nature of information regarding industry costs and earnings and because of the limited manufacturers' data on costs of control systems. The demand for lead appears relatively inelastic so that cost increases in the range of 5 percent or less would probably be passed along to the consumer without significant effect on the average net income for the industry as a whole. It is problematic whether small companies requiring new plants or modification might be so adversely affected by even slight cost increases as to accelerate the existing trend towards concentration of production within the industry in a few large companies. There is also the question of competition between new plants faced with increased expenditures for SO_2 control and older plants able to operate without such costs.

In view of all of the uncertainties, it is concluded that the question of NSPS for SO_2 emissions from secondary lead smelters should be investigated. Consideration of a possible standard is based on two principal factors: (1) the state of SO_2 control technology that appears applicable to secondary lead furnaces, and (2) the relatively high rate of uncontrolled emissions of SO_2 that

is estimated to occur from these plants. It is recommended that the following investigations be undertaken:

- Comprehensive data on emission rates of SO_2 from plants now controlled under current NSPS should be assembled and analyzed to assess the need for a regulatory standard. Information now available reflects the general estimates of AP-42 and a few pre-1974 test results which are inconclusive and show a wide range.

- More comprehensive and detailed surveys should be made of manufacturer capabilities and costs involved in supplying combined systems for SO_2 and particulate removal, with particular reference to plant smelters of different size and operating conditions and to the needs of smaller plants (under 50 ton/day capacity).

- Achieved efficiencies for such combined systems should be determined in terms of SO_2 reduction and particulate removal, and the relationship of efficiency to cost should be assessed.

- The probable economic impacts of a regulatory standard on the secondary lead industry should be thoroughly assessed in terms of its ability to afford SO_2 controls. Issues to address would include the ability to pass on costs and the effects on the competitive position of smaller plants and of new plants vs. existing ones.

2.0 INTRODUCTION

The Clean Air Act of 1977 requires that the NSPS be reviewed every 4 years. The levels of performance achievable under best available control technology are compared with existing NSPS. Estimated energy needs, environmental effects produced by emission controls and potential effects on industrial operations are also considered.

Results of testing emissions from secondary lead smelters under NSPS are examined. Only four results were available from tests conducted for EPA regions and state agencies.

Possible revisions to the standards are analyzed with particular attention given to changes in acceptable emission levels, additions to the pollutants controlled, and process facilities regulated. The probable effects of changes in standards and/or associated regulations are considered with respect to the environment and industry. Specific recommendations are made regarding standards and unresolved issues are addressed.

3.0 CURRENT STANDARDS FOR SECONDARY LEAD SMELTERS

New Source Performance Standards were adopted on March 8, 1974, which specified allowable levels of emissions from several industrial sources, including secondary lead smelters (40 CFR 60). Any secondary lead smelter under construction, modification, or reconstruction on or after June 11, 1973, became subject to NSPS. The NSPS for secondary lead smelters were revised April 17, 1974 and October 6, 1975.

3.1 Affected Facilities

Facilities in a secondary lead smelter that are subject to NSPS are reverberatory furnaces (stationary, rotating, rocking, or tilting), blast (cupola) furnaces, and pot furnaces of more than 550-lb charging capacity (EPA, 1977). Furnaces for smelting lead alloy for newspaper linotype are subject to the standards if they meet the same size requirement as applied to pot furnaces. Also affected by NSPS are modified secondary lead smelters (a physical or operational change that increases the emission rate of any pollutant) and reconstructed secondary lead smelters in which the replacement cost of components exceeds 50 percent of the cost of building a comparable new facility.

3.2 Pollutants Controlled and Emission Levels

Particulate emissions from secondary lead smelters are subject to regulatory control. Approximately 7 percent of a charge from such a smelter is lost or released in the forms of fumes and particulate matter: smoke, dirt, limestone, coke dust, fuel bits, and metal

oxides--specifically oxides (or sulfides) of lead (EPA, 1977). As stated in 40 CFR 60, no owner or operator of a secondary lead smelter under construction on or after June 11, 1973 shall discharge or cause the discharge into the atmosphere from any affected facility any gases which:

- Contain particulate matter in excess of 50 mg/dscm (0.022 gr/dscf).
- Exhibit 20 percent opacity or greater; or 10 percent opacity or greater in the case of gases discharged from a pot furnace larger than 550-lb charging capacity (EPA, 1977).

3.3 Performance Test

A performance test of a secondary lead smelter must be conducted within 60 days after the facility has achieved its maximum production rate and not later than 180 days after its initial startup, and at such other times specified by the Administrator. Such a test consists of three separate runs of which the arithmetic mean is the result for determining compliance with NSPS.

No continuous monitoring requirement is set for secondary lead smelters (40 CFR 60).

3.4 Definitions Applicable to Secondary Lead Smelters

Terms applicable to secondary lead smelters as defined in 40 CFR 60 include:

- Affected facility - with reference to a stationary source, any apparatus to which a standard is applicable.
- Lead - elemental lead or alloys in which the predominant component is lead.

- Modification - any physical change in, or change in the method of operation of, an existing facility which increases the amount of any air pollutant (to which a standard applies) emitted into the atmosphere by that facility or which results in the emission of any air pollutant (to which a standard applies) into the atmosphere not previously emitted.

- Opacity - the degree to which emissions reduce the transmission of light and obscure the view of an object in the background.

- Particulate matter - any finely divided solid or liquid material, other than combined water, as measured by Method 5 of Appendix A to this part [Subpart A] or an equivalent or alternative method.

- Reconstruction - the replacement of components in an existing facility to such an extent that: (1) the fixed capital cost of the new components exceeds 50 percent of the fixed capital cost that would be required to construct a comparable entirely new facility, and (2) it is technologically and economically feasible to meet the applicable standards set forth in this part.

- Reverberatory furnace - includes the following types: stationary, rotating, rocking, and tilting.

- Run - the net period of time during which an emission sample is collected. Unless otherwise specified, a run may be either intermittent or continuous within the limits of good engineering practices.

- Sampling time [for Method 5] - for each run shall be at least 60 minutes and the sampling rate shall be at least 0.7 dscm/hr (0.53 dscf/min) except that shorter sampling times, may when necessitated by process variables or other factors, be approved by the Administrator.

- Secondary lead smelter - any facility producing lead from a lead bearing scrap material by smelting to the metallic form.

- Shutdown - the cessation of operation of an affected facility for any purpose.

- Startup - the setting in operation of an affected facility for any purpose.

- Test methods (explained in Appendix A of 40 CFR 60) -

  - Method 1 to determine sample and velocity transverses
  - Method 2 to determine velocity and volumetric flow rate
  - Method 3 for gas analysis
  - Method 5 to determine the concentration of particulate matter and the associated moisture content

  Sampling shall be conducted during representative periods of furnace operation, including charging and tapping.

3.5 Regulatory Basis for Any Waivers, Exemptions, or Other Tolerances

Occasionally, opacity standards do not apply, such as during periods of startup, shutdown, and malfunction, or during periods of excess emissions caused by post-blowing, unstable process conditions, or emissions of uncombined water vapor (EPA, 1977). In addition, when acceptable systems of emission reduction cannot meet the opacity limits, a means is provided for exempting the source from the standard at that time (39 FR 9309, March 8, 1974).

4.0 STATUS OF CONTROL TECHNOLOGY

4.1 Scope of Industrial Operations

4.1.1 Production of Secondary Lead

Lead occupies a unique position among nonferrous metals in that secondary lead production relies heavily on one source of scrap--used batteries. More than 60 percent of all secondary lead is derived from resmelting battery-lead plates. Other sources include pipe, cable covering, type metal, solder, drosses and other by-products. Return slag from smelting is also reused (Bureau of Mines, 1973, 1976; Engineering-Science, Inc., 1977).

Secondary lead is smelted down from so-called old and new scrap leads. Old scrap lead consists of discarded, dismantled, or worn-out metallic items. New scrap or "prompt industrial scrap" is lead generated at various points of the production process. It has never been made into or used as an end product and is supplied directly to smelters in larger, more uniform lots than old scrap (Fine et al., 1973). Consumption of these various kinds of scrap lead is shown in Table 4-1.

Secondary lead competes widely with primary lead, since most of the same product needs can be met from both sources. In 1975, the output of secondary lead (658,500 tons) represented approximately 51 percent of the total U.S. lead consumption. The 1975 production of secondary lead was about 6 percent below the output of approximately 700,530 tons in 1974. Although the decrease in recycled lead from

1974 is not fully explained, it was part of an overall drop in total production and consumption of lead both in the U.S. and internationally. The Bureau of Mines (1975) noted a worldwide recession and a decrease in demand for lead in automobile batteries. Secondary lead production rose to a record 726,569 tons in 1976, then dropped again in 1977 to a total estimated amount of 588,000 to 600,000 tons. Overall, the increase in production of secondary lead by smelting of

TABLE 4-1

CONSUMPTION OF SCRAP LEAD IN THE U.S.

Scrap Lead Type	Amount Used By Remelters, Smelters, Refiners (tons)			
	New[a]		Old[b]	
	1972[c]	1975[d]	1972[c]	1975[d]
Soft Lead	-	-	57,674	32,642
Hard Lead	-	-	15,402	26,912
Cable Lead	-	-	31,909	50,569
Battery Plates	-	-	520,913	623,448
Mixed Babbitt	-	-	4,270	3,515
Solder and Tinny Lead	-	-	11,853	11,250
Type Metals	-	-	32,462	19,820
Dross and Residues	114,988	136,066	-	-
Total	114,988	136,066	674,483	768,156

[a]Scrap lead never made into or used as an end product. It is available in larger, more uniform lots than old scrap.

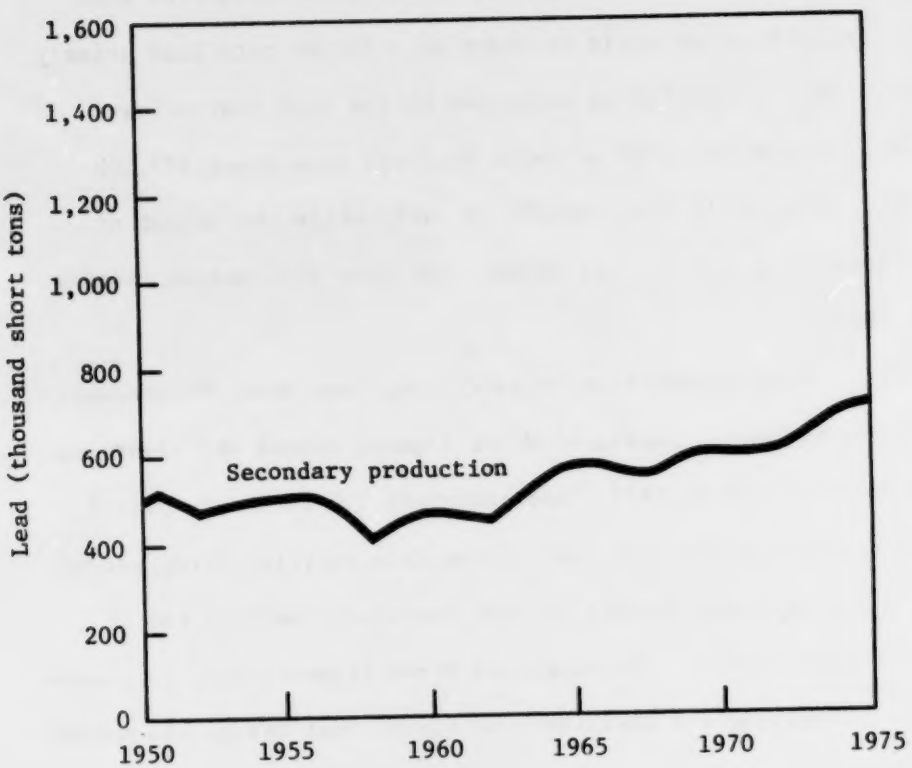
[b]Scrap lead that is a discarded, dismantled, or worn-out metallic element.

[c]American Metal Market, 1972.

[d]Bureau of Mines, 1975.

discarded metal from about 500,000 tons in 1955 to over 658,500 tons in 1975 (Figure 4-1) represents an average annual growth rate of about 1.4 percent. However, decreases in the annual production of secondary lead have also occurred in recent years. Early in the 1970s the Lead Industry Association (1972) predicted a possible excess of lead supply over demand before 1980. The Bureau of Mines (1973) predicted that secondary lead production would increase at a faster rate than primary production. This projection is supported by the fact that primary production from domestic ores actually declined from about 573,000 tons in 1971 to slightly over 530,000 in 1975, while the output of secondary lead increased by over 50,000 tons over that period (Bureau of Mines, 1975).

In 1975, the secondary lead industry comprised about 85 predominantly small companies. Bureau of Mines figures showed 160 plants in 1967, 140 in 1973, and in 1975, "approximately 115 secondary plants engaged in recovering lead and lead alloys from recycled scrap materials." By 1977, the total number of such secondary smelters had decreased further to 104. The Bureau of Mines figures apply to plants which conduct smelting and auxiliary operations that change the nature of the product metal from the state in which it is charged to the furnace (Bureau of Mines, 1973, 1978). The average output per plant in any given year is in the range of 5700 to 6000 tons. However, a very wide variation occurs in annual production for individual smelters. Viewed over a period of months, production of secondary



Source: Bureau of Mines, 1975.

FIGURE 4-1
U.S. SECONDARY LEAD PRODUCTION

lead is an intermittent operation. It is unusual for a smelter to operate continuously up to capacity. Plants may be shut down for a period of time and started up again when market conditions are more favorable (Bureau of Mines, 1978). Therefore, annual production of a plant is not be directly determined by daily capacity or vice versa.

The high degree of domination by a few companies in the secondary lead industry is shown by the fact that the two largest producers, operating 18 smelters, provided over half the total U.S. output in 1975. Informal estimates are that by 1977, their share of the market may have been nearly 60 percent. More than 50 percent of the remaining output (or some 20 percent of the total) is produced in 24 smelters operated by 13 other companies (Bureau of Mines, 1977; 1978). Since more than 3/4 of the output comes from these 42 plants, the total production of the remaining 70 small firms cannot exceed 24 percent of total output and may be nearer 12 percent. Earlier estimates ascribed about 75 percent of production to four firms (EPA, 1973). Production data are regarded as proprietary, particularly among the smaller firms and further details on distribution of output are not available. However, a range of estimates can be made (Table 4-2). Estimates of production among the three categories of secondary lead firms, annual averages per smelter, and average number of operating days per year based on assumed plant capacity. Estimates in this table as to share of production captured by the largest producers are conservative.

TABLE 4-2

ESTIMATED PRODUCTION OF SECONDARY LEAD

Category	Number of Companies	Total Production, %	Annual Production[b] Category	Annual Production[b] Per Co.	Number of Smelters	Annual Production Per Smelter	Operating Days/Year Based on Selected Averages for Smelter Capacity (TPD) 20	35	50	60	80
Large Producers	2	51	336,000	118,000	18	18,660[b]	N/A	N/A	N/A	311	233
Other Major Producers	13	25	165,000	12,690	24	6,875	N/A	196	138	115	N/A
Small Producers	70[a]	24	158,000	2,260	73	2,164	108	62	43	N/A	N/A
Total	85	100	659,000	7,750	115	5,730	-	-	-	-	-

[a] Estimated from available approximations (1976).
[b] Rounded-off.

Source: Bureau of Mines, 1975; 1977.

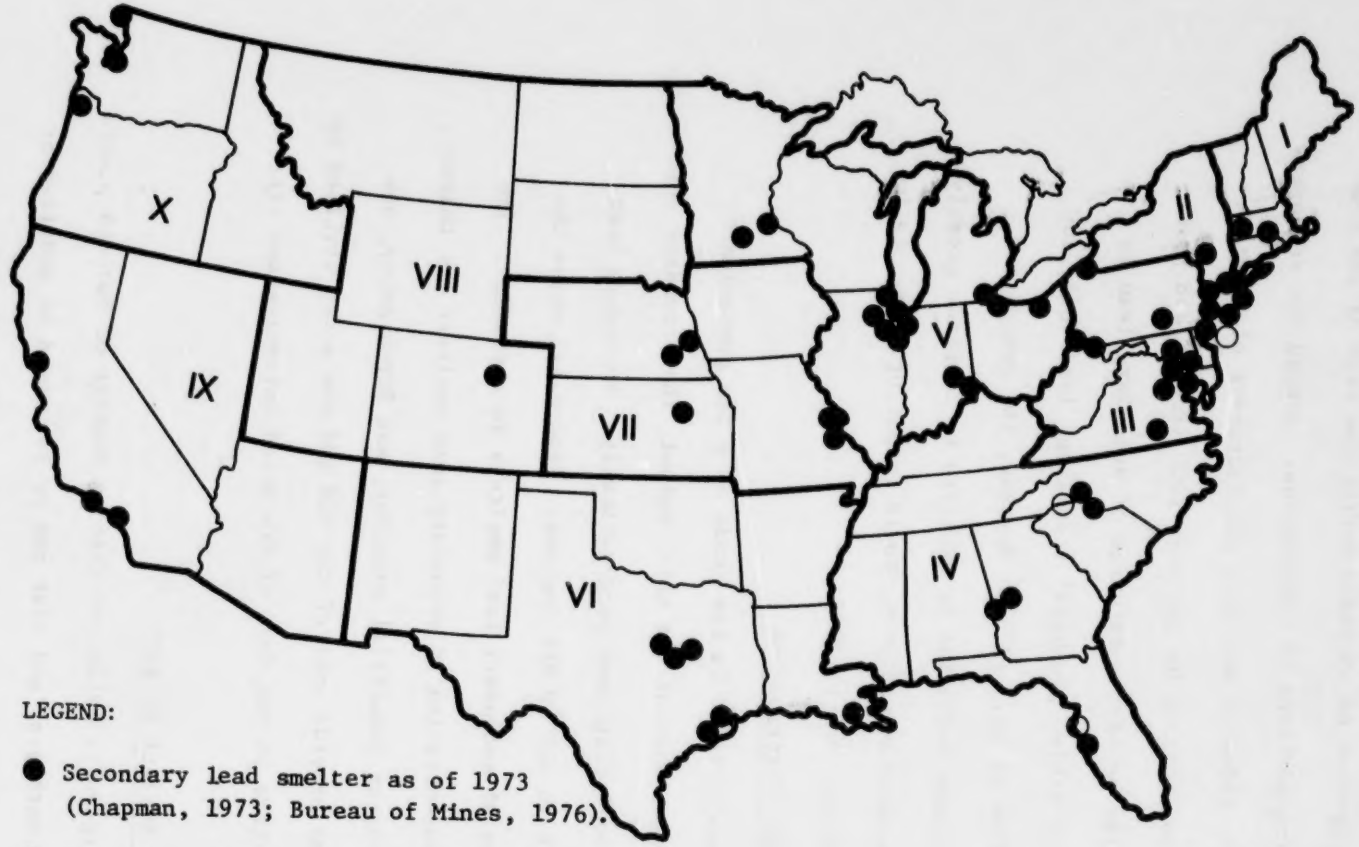
Use of lead is expected to increase during the rest of the century marked by changing patterns in consumption. Demand for secondary lead from the printing industry and from manufacturers of paint pigment is expected to decrease by the year 2000 (Brobst and Pratt, 1973). There will also be decreased usage of secondary lead in gasoline, lead covered cable, plumbers' (caulking) lead foil, and collapsible tubes (Fine et al., 1973). However, the demand for secondary lead in storage batteries is expected to increase greatly and, according to an extreme estimate, could triple or quadruple by the year 2000 (Brobst and Pratt, 1973).

4.1.2 Geographic Distribution

Despite its concentration in the hands of a few predominant companies which produce most of the total output, the secondary lead industry is fairly well dispersed geographically. Secondary lead smelters are present in all 10 EPA regions. Figure 4-2 shows the general distribution of secondary lead smelters in operation. The areas of highest concentration of secondary lead smelters are Chicago, the Baltimore-Washington industrial corridor, and Perth Amboy, New Jersey. These areas provide most of the old and new scrap utilized by secondary lead smelters in the form of discarded batteries and zinc and copper alloys.

4.1.3 Plants Subject to NSPS

EPA (1973) originally estimated that an average of two new plants would come on line each year and that one or two would be modified or reconstructed. This estimate correlates reasonably well with



LEGEND:

● Secondary lead smelter as of 1973 (Chapman, 1973; Bureau of Mines, 1976).

○ Secondary lead smelter under construction in 1978 (MITRE Corporation, 1978).

FIGURE 4-2
SECONDARY LEAD SMELTERS

projections based on the average annual growth rate of the secondary lead industry (1.4 percent). The estimate of about three new plants every 2 years does not take into account new plants added to replace old ones. Of course, no estimate of reconstructed or modified plants is provided by projections based on the industry growth rate.

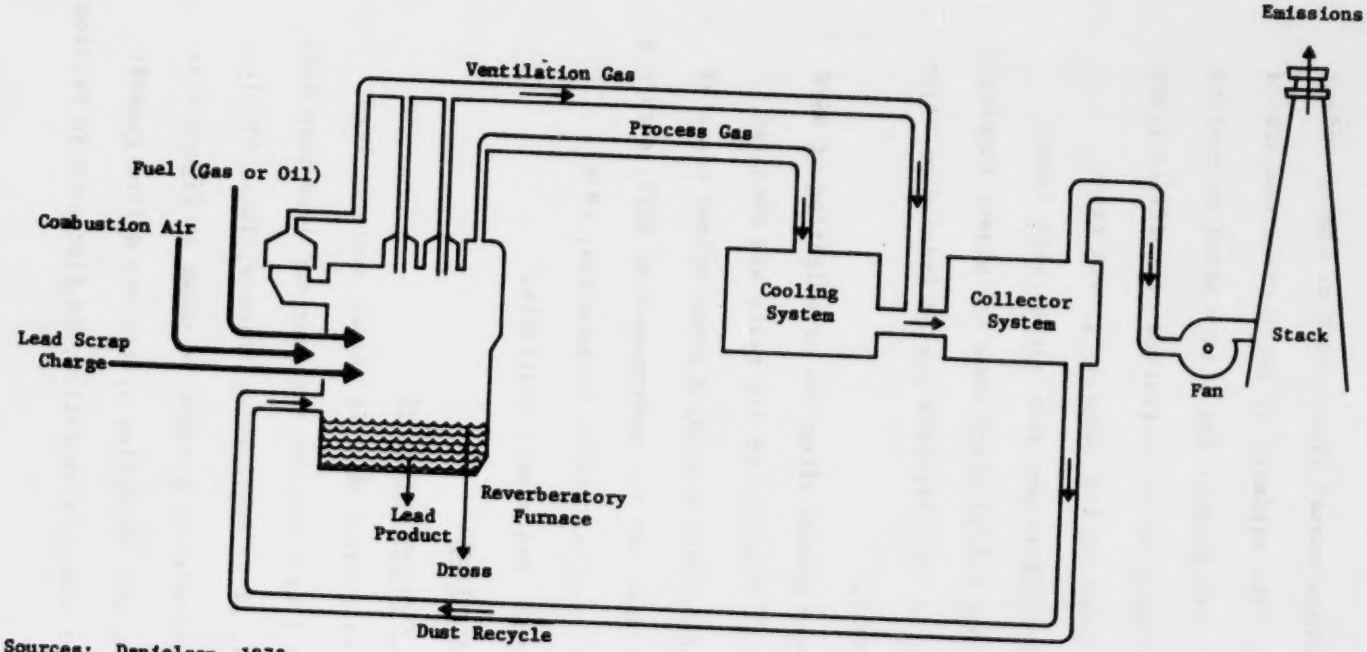
The estimates of two new plants per year agrees with latest figures of the Bureau of Mines (1978) which show six plants completed or scheduled for completion in the 1977-1979 period (including major expansions of existing plants).

At least six plants were tested after the promulgation of NSPS for secondary lead smelters. Evidence of six tests was obtained chiefly through the Compliance Data System, a computerized means of recording information necessary for the enforcement of NSPS, during a recent survey of the 10 EPA regions (MITRE Corporation, 1978). However, results of only four tests were available.

4.2 Production of Secondary Lead

4.2.1 Reverberatory Furnace Operation

Reverberatory furnaces produce what is termed semisoft lead, containing typically from 3 to 4 percent antimony and less than 0.05 percent copper (Danielson, 1973; Engineering-Science, Inc., 1977). The process flow in a reverberatory furnace is shown in Figure 4-3. The details of the cooling and collecting system may differ greatly, depending upon the type of controls installed, as discussed in Section 4.3.



Sources: Danielson, 1973.
EPA, 1973
Mantell, 1975.
Engineering-Science, Inc., 1977.

FIGURE 4-3
LEAD REVERBERATORY FURNACE

When a smelter is operating, reverberatory furnaces may operate on a continuous basis, and are used in sweating operations and in reclaiming lead from oxides and drosses. Sweating utilizes differences in melting point temperatures to separate lead from other metals. Material for sweating and for reclamation from lead oxides and drosses may be charged in the reverberatory furnace at one time. Such a furnace radiates heat from burners and the refractory lining into the metal charge within it. The furnace operates at a temperature of about 2300°F and at near atmospheric pressure so that air will not leak in. Air blown through the molten metal eliminates impurities. Attempts are made to keep as much heat as possible in the furnace. Only enough draft is provided to remove smoke and fumes. Dross formed in the furnace floats on top of the molten metal and is removed periodically in an operation known as slagging. The slag may be later rerun in a blast furnace. The lead product is periodically tapped into molds.

External hoods are used with the objective of passing all smoke and fumes to a collector. To keep cool air out of the furnace, ventilating air for all the hoods is similarly vented. The spout through which the molten lead product pours is the only exception to the hooding. The collected dust is valuable for recycling as fines, either in a reverberatory or a blast furnace. In a continuous operation, a typical weight balance of material shows:

- 47 percent metal recovery as lead product

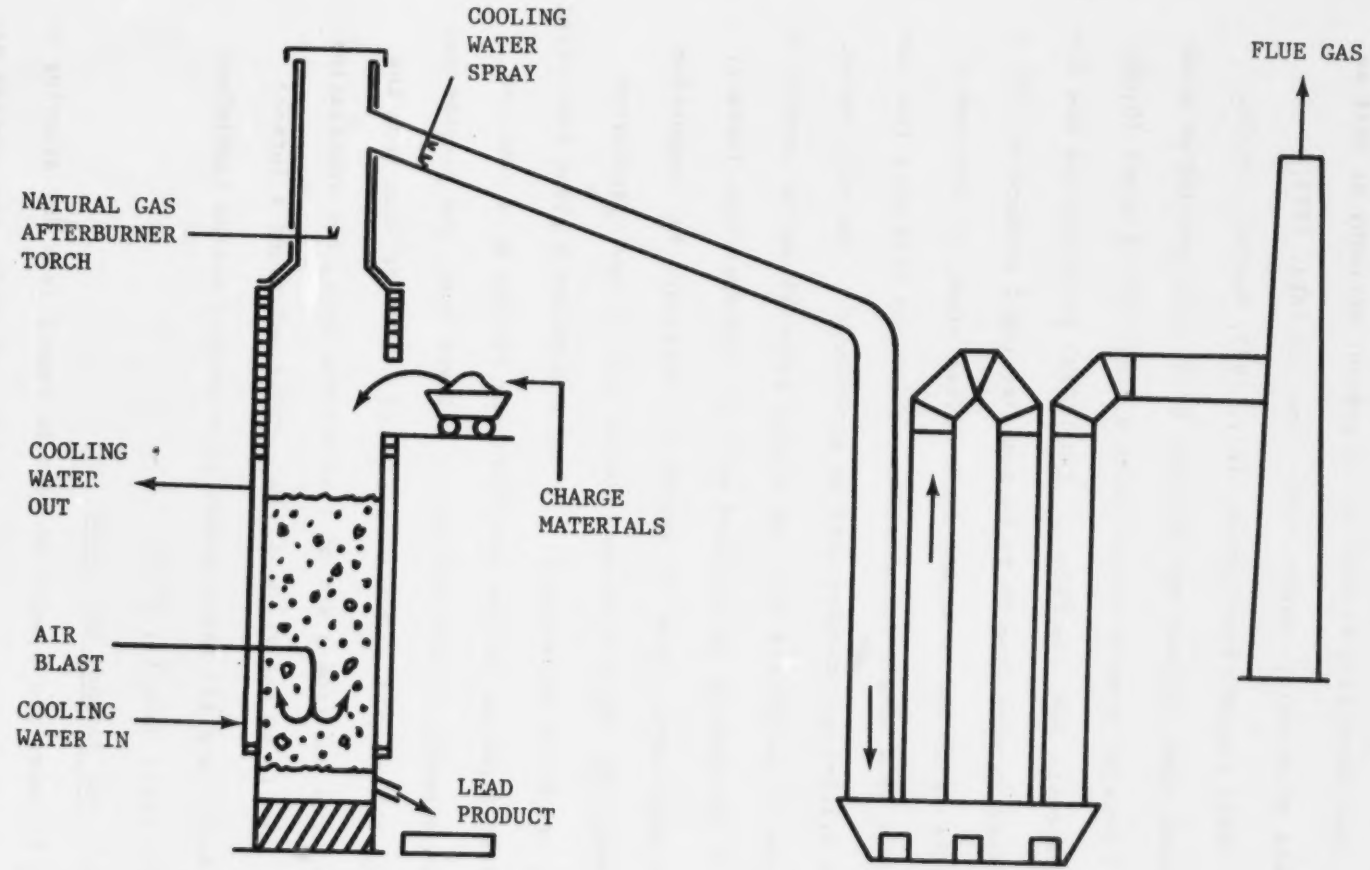
- 46 percent recovery of slag, which may be at least partially recharged
- 7 percent loss as smoke and fumes (Danielson, 1973; Engineering-Science, Inc., 1977).

4.2.2 Blast Furnace Operation

A blast (cupola) furnace is cylindrical and vertically oriented and is batch-fed from a car or hopper near the top at a fairly constant rate (Figure 4-4). Although material content varies somewhat, a typical charge may consist of:

- 82.5 percent drosses, oxides and slags, including material rerun from reverberatory furnaces and pot-furnace refining
- 4.5 percent highly silicated slag rerun from previous blast furnace operation
- 4.5 percent cast-iron scrap
- 3 percent limestone
- 5.5 percent coke.

Smaller percentages of iron may be used, while the percentages of rerun slags, limestone and coke may run as high as 8, 10 and 8, respectively. The combustion of coke furnishes heat for the process and also facilitates chemical reduction of lead oxide in the feed. Forced air, which may be oxygen enriched, is introduced near the bottom through openings known as tuyeres at a gage pressure of about 8 to 12 oz/in^2. Slag floating on top retards oxidation and is tapped periodically. About 5 percent of the recovered slag may be rerun later. The lead product is drawn off more or less continuously from the bottom and may be retained in lead holding pots for further melting and refining. Blast furnaces produce what is termed hard or



Source: EPA, 1973.

FIGURE 4-4
PROCESS FLOW SKETCH OF LEAD BLAST FURNACE
OF CUPOLA WITH COOLING SYSTEM

antimonial lead containing as much as 10 percent antimony as well as small amounts of arsenic, copper, nickel and tin (EPA, 1973; Danielson, 1967; Engineering-Science, Inc., 1977; Mantell, 1975).

A typical blast furnace may be rated at 50 tons per day of product (over 2 tons/hr process weight) with a flow rate of about 15,000 dry standard cubic feet (dscf)/min. EPA (1973) projected the new furnaces to range in size from 20 to 80 tons/day ingot production with a gas flow rate of 10,000 to 40,000 dscf. Often blast and reverberatory furnaces in a single installation combine the effluents that are run into a brick-lined chamber with an afterburner. The afterburner is necessary to incinerate oily and sticky material and to convert CO to CO_2. No afterburner is required with the reverberatory furnace, previously mentioned, since the excess air necessary for combustion and the operating temperature used ensure that CO and hydrocarbon materials are fully incinerated. In one Pennsylvania plant consisting of two blast furnaces and one reverberatory furnace at a combined production capacity of 100 tons/day of alloyed lead, the process gas flows into the control system at a rate of 65,000 ft^3/min from the three furnaces and from a set of lead holding pots; the ventilation gas flow rate is 60,000 ft^3/min. To contain emissions a furnace must be sealed and all gases vented to a control system (Danielson, 1967; EPA, 1973; Mantell, 1975).

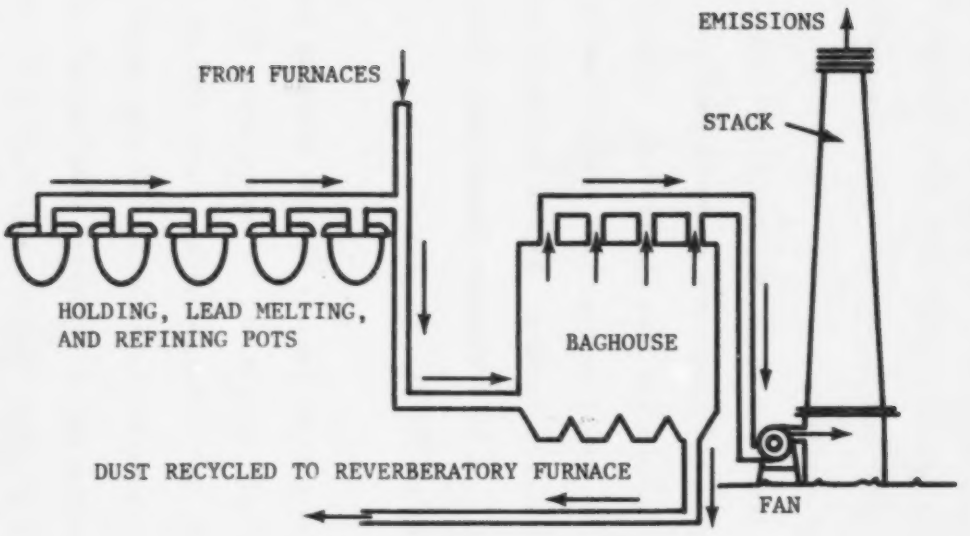
4.2.3 Pot Furnace Operation

Pot furnaces use a batch process to remelt lead for alloying or refining. At a temperature range of 600° and 900°F, the process may

require from a few hours to more than 2 days. The metal is fed into open top kettles that are ceramic lined and usually fired by natural gas burners placed underneath. The open top of the pot is hooded so that lead oxide fumes will not escape into the working area. A soft lead of high purity (which may exceed 99.9 percent lead) can be produced by the removal of copper and antimony. A hard lead product results from removing arsenic, copper and nickel. For alloying, ingots of a specified metal are added in the desired percentages. Copper, tin, arsenic, antimony, and nickel are commonly employed in alloys. Emissions from the furnace and from the holding, melting and refining pots are vented to a control system. The lead-containing dust is recycled to a reverberatory furnace. Figure 4-5 shows the gas flow for a pot furnace controlled by a baghouse (Danielson, 1967; EPA, 1973; Engineering-Science, Inc., 1977).

4.3 Pollutant Emissions

Emissions may occur from a blast furnace via the charging doors and metal tapping spout, as well as from the furnace stack. These outlets are hooded to provide for venting dust and fumes through the control system. In the reverberatory furnace the charging point, the furnace itself, and the repositories of recovered slag and metallic lead are hooded. Hooding is also provided for emissions from holding, melting and refining pots. Depending on the efficiency of the hoods in trapping dust and smoke, some may escape as fugitive emissions. In a pot furnace only the open top of the pot provides a source of emissions (Engineering-Science, Inc., 1977; EPA, 1973).



Source: EPA, 1973.

FIGURE 4-5
CONTROLLED LEAD POT AND VENTILATION SYSTEM WITH BAGHOUSE

Particulate emissions from blast and reverberatory furnaces contain oxides and sulfides of lead, small amounts of other elements, coke fuel, and oil vapor. The high temperature used in a reverberatory furnace (approximately 2300°F) accounts for a relatively high mean loading (in pounds per ton of charge) of oxides of sulfur, chiefly SO_2. The sulfuric acid in lead batteries smelted accounts for much of the sulfur emissions from a typical furnace, along with casings and other impurities charged. On the basis of 7 percent loss of charge, uncontrolled particulate emissions would be on the order of 140 lb/ton of material charged to the furnace. Tests have shown that the actual particulate emission rate varies widely. Estimates by EPA are shown in Table 4-3. Particulate emissions from pot furnaces are more than two orders of magnitude lower than from blast or reverberatory furnaces, less than 1 lb/ton charged to the furnace. A relatively low temperature is used with pot furnaces, and there is less turbulence than with the other types.

The particulates emitted by secondary lead smelters are high in lead content, chiefly in the form of lead oxide. It has been estimated that on an uncontrolled basis lead emissions from blast and reverberatory furnaces amount to about 56 and 53 lb/ton of product, respectively, which is approximately 23 percent of the total particulate emission rate (EPA, 1977).

The concentration of particulate matter in emissions from blast furnaces (prior to application of control) may be high, as much as 12.3 gr/dscf in one test reported. Typical ranges for concentration

TABLE 4-3

SECONDARY LEAD SMELTERS
ESTIMATED UNCONTROLLED EMISSION RATES
(lb/ton charge)

Test Data	Reverberatory Furnace		Blast Furnace		Pot Furnace	
	Particulates	SO_2	Particulates	SO_2	Particulates	SO_2
• RANGE						
AP-42	56-313	71-88	21-381	18-110	N/A	Negligible
Tests Reported by EPA[a]	N/A	109-185	N/A	0.1-64	N/A	N/A
• MEAN OR SINGLE VALUE						
Danielson (1 Test)[b]	104	N/A	172	N/A	N/A	N/A
Tests Reported by EPA (Average)[a]	N/A	146	N/A	41	N/A	N/A
AP-42	147	80	193	53	0.8	Negligible
Danielson (Weight Balance)[b,c]	140	N/A	140	N/A	N/A	N/A

[a]Background Information, Vol. I, June, 1973.

[b]Air Pollution Engineering Manual, 2d Ed. (EPA, 1973).

[c]7% of charge estimated carried out as dust in smoke and fumes.

of particulates in stack gases from reverberatory furnaces are reported to be from 1.4 to 4.5 gr/dscf, but higher values occur, such as 4.98 gr/dscf (Danielson, 1973; Engineering-Science, Inc., 1977; EPA, 1975).

Particles emitted from blast furnaces are much larger than those from reverberatory furnaces and range in size from 1 to 100 microns. By contrast, particulate sizes from reverberatory furnaces range between 0.07 and 0.4 microns (as determined from analysis of baghouse content) with a reported mean size of 0.3 microns. These particles are nearly spherical and have a tendency to agglomerate (Danielson, 1973; Engineering-Science, 1977).

On the average, SO_2 emissions from reverberatory furnaces are higher (Table 4-3) than those from blast furnaces 80 and 53 lb/ton of charge, respectively. However, the upper limit of the range of emissions from blast furnaces exceeds that for furnaces of the reverberatory type. Pot furnaces emit only negligible amounts of SO_2.

Emission factors from furnaces used in secondary lead smelters have not been determined as explicit functions of the variables that affect them. However, a number of factors that influence the emission rate have been briefly presented in the Inspection Manual for Enforcement of New Source Performance Standards, Secondary Lead Smelters (Engineering-Science, Inc., 1977). These include:

- production rate

- quality of charge (i.e., increase in dirt or oil on the scrap increases emissions)
- method of charge (i.e., adding essentially all of the charge at the beginning of the heating process results in lower emissions than by intermittently charging a hot operating furnace)
- fuel rate
- oxygen rate
- slag cover (i.e., a thick layer tends to harden, increasing lead oxide emissions; prior to the time of hardening mass emissions are decreased by a thick layer)
- length of time over which a charge is smelted
- slag fines charged to the furnace (i.e., an increase in these results in a higher rate of particulate emissions)
- for blast furnace, rate of air blowing through the tuyeres.

4.4 Applicable Controls

4.4.1 Methods and Effectiveness

In the past, various control methods have been used in secondary lead smelters to meet state and local requirements for particulate removal and to recover the lead dust valuable for recycling. These have included centrifugal dust collectors, settling chambers and low-energy scrubbers. In the Background Information Document for the proposed NSPS, EPA noted that "At well controlled secondary lead smelters, either baghouses or high-energy scrubbers are used to collect dust and fumes from the furnace." The Agency predicted further "The predominant control devices for the secondary lead industry are expected to be fabric filters, along with a small number of high-energy scrubbers." (EPA, 1973). Some authorities consider

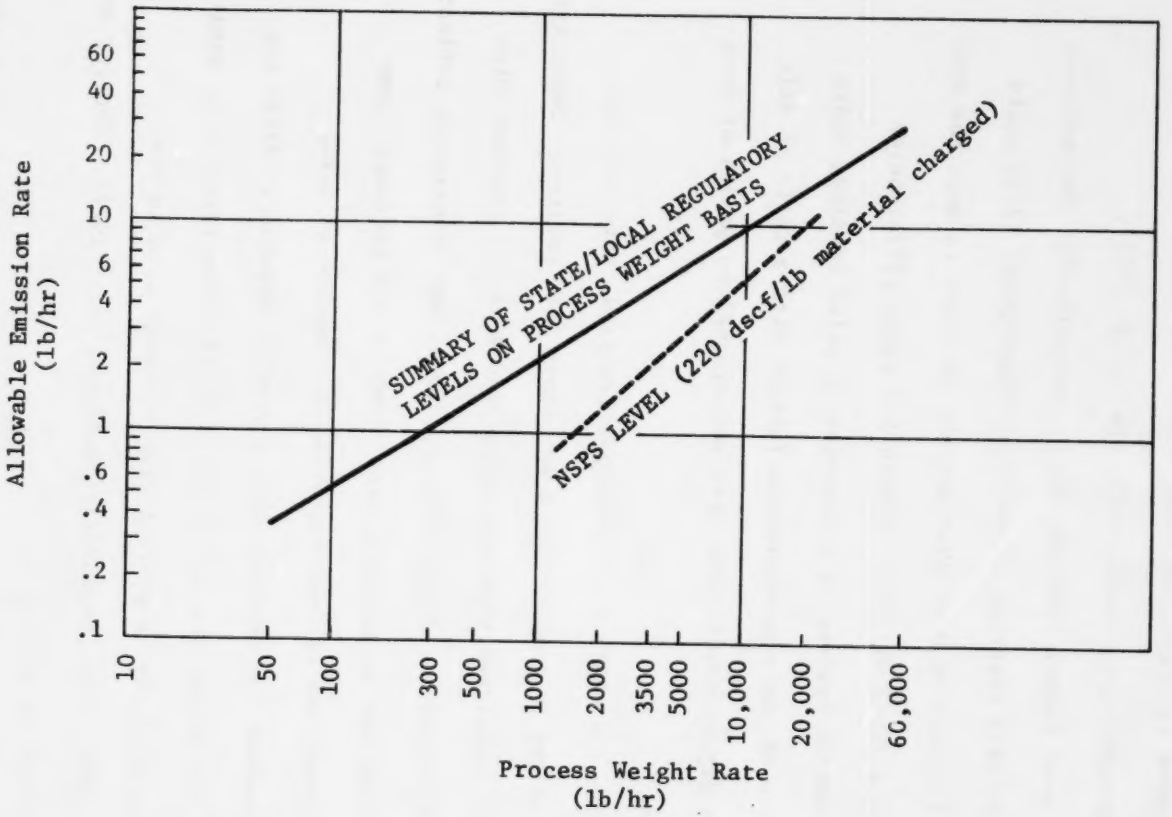
the baghouse to be the most effective control system (Danielson, 1975; EPA, 1977), and the use of fabric filters predominates over use of venturi scrubbers in the secondary lead industry (Engineering-Science, 1977).

Baghouses used to control emissions from secondary lead smelters commonly employ a pull-through, tubular bag made of either dacron or fiberglass. To facilitate maintenance, the baghouses are usually compartmentalized. Because the temperature of the gas is very high when it leaves the furnace stack (up to 1350°F), it is necessary to employ cooling measures that reduce the temperature to about 500°F for fiberglass fabric filters and about 300°F for dacron filters. Temperature is reduced by passing the gas through radiant or water-jacketed cooling ducts. The cooling duct system may use a water spray and/or U-tube coolers. Although dilution air may also be introduced to effect cooling, the volume of gas that may be pulled is limited by the capacity of the system fan, so that the success of the system depends on radiation and/or water-cooling. It is also necessary to ensure that sparks and other burning material do not come in contact with the fabric of the filter bag. As previously noted, with blast furnaces an afterburner is employed to ensure complete combustion of such material before it enters the baghouse. To prevent condensation within the baghouse, the entering gas temperature must be maintained at 50°F above the dewpoint; otherwise condensation results in caking on the bags and a pressure buildup that will ultimately rupture the fabric. Also, sulfur in the cake forms damaging acids. A ratio of air to

cloth of about 2:1 is commonly employed. The pressure drop is usually up to 4 inches water gauge (WG) (Danielson, 1973; Engineering-Science, Inc., 1977).

Venturi scrubbers are also used for emission control, although less widely than baghouses. These scrubbers commonly employ a pressure drop between 30 and 100 inches WG. Efficiency of the scrubber is affected principally by the pressure drop and secondarily by the rate of water flow. A water quench is typically used which lowers gas temperature. With a pressure drop of 60 inches, a throat velocity of about 200 ft/s and a water flow of 3 gal/min is typically used.

Figure 4-6 compares the more rigorous requirements of the current NSPS for particulate emissions from secondary lead smelters with those provided by earlier EPA guidelines for State Implementation Plans (SIP). The SIP formula specified maximum allowable emission rates in pounds per hour as a function of hourly processing weight. To facilitate comparison, the graph of the permissible level under NSPS has been converted to the same units of measure as SIPs, on the basis of a representative furnace with a daily capacity of 50 tons of product (EPA, 1973) and a flow rate of 15,000 scf/min. Such a plant producing 4160 lb/hr (2.08 tons/hr) would be allowed to emit up to 2.72 lb of particulates per hour. An uncontrolled emission rate from such a plant of 150 lb/ton of product (Table 4-3) would produce an hourly inlet loading to the control system of 312 lb, requiring an efficiency



Source: U.S. Environmental Protection Agency, 1973

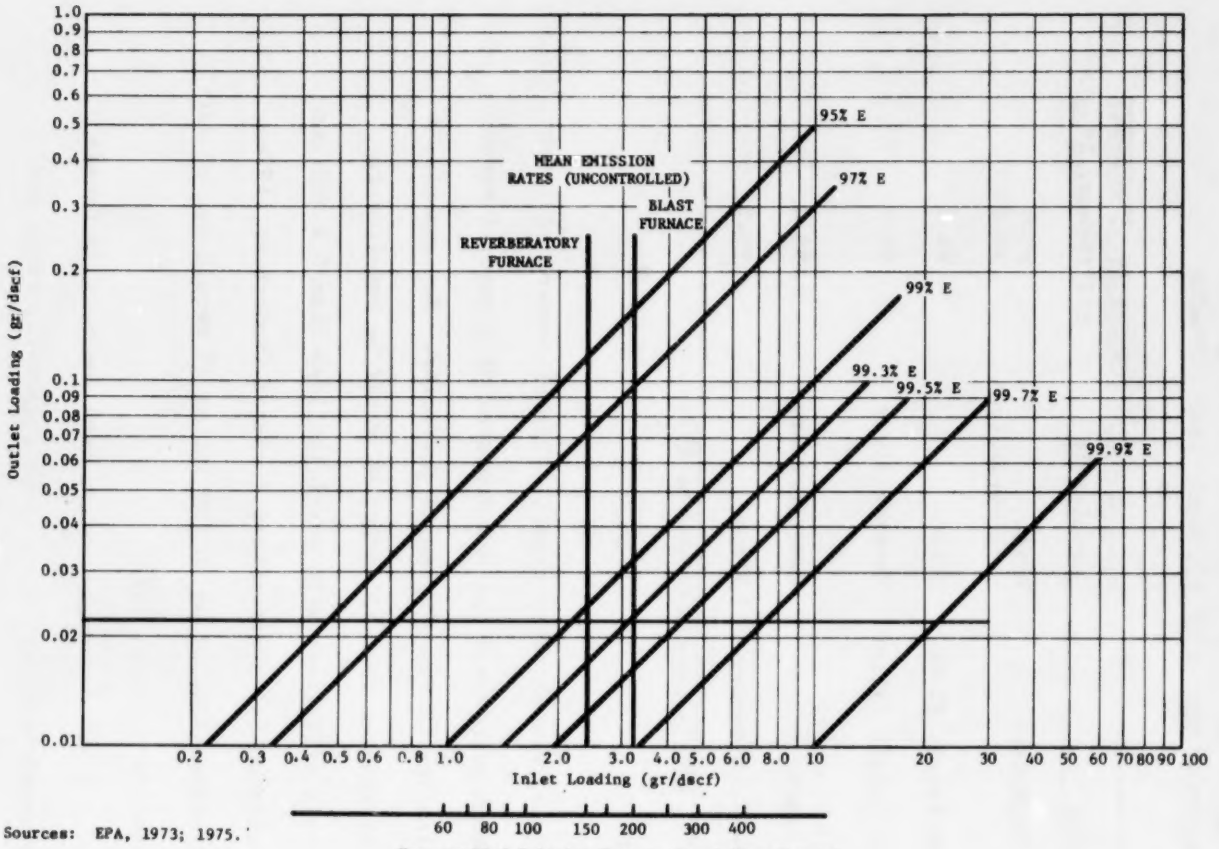
FIGURE 4-6
COMPARISON OF ALLOWABLE EMISSIONS FOR PARTICULATES (50 TO 50,000 LB/HR) VS. PROCESS WEIGHT FOR NSPS AND STATE IMPLEMENTATION PLANS

of 99.1 percent; whereas an uncontrolled rate of 193 lb/ton (average for blast furnaces as listed in Table 4-3) would require an efficiency of over 99.3 percent (Danielson, 1973; EPA, 1973; 1975).

However, even higher loadings may be encountered. The achievement of 12.3 gr/dscf reported in one test (Danielson, 1973) would require an efficiency of over 99.8 percent in order to meet the NSPS level of 0.022 gr/dscf or less. Figure 4-7 shows efficiencies required of control systems as a function of inlet loading, again using the basis of the representative furnace with a ratio of exit flow-rate (in dry standard cubic feet per minute) to pounds of lead produced of 220.

To achieve the control efficiencies required, more than one control system may be combined in a secondary lead smelter. Table 4-4 shows systems associated with secondary lead furnaces together with estimated efficiencies. These efficiencies do not necessarily reflect BTS. A baghouse may be combined with a wet or dry cyclone. Some plants with heavy use of lead batteries as a source of scrap reportedly combine the baghouse with a venturi scrubber. After the exhaust gas has passed through a fabric filter, the scrubber is used to remove SO_2 that may be present from sulfuric acid in the batteries. (EPA, 1975; Engineering-Science, Inc., 1977). Control of SO_2 is discussed in Section 6.

Current control technology provides for the high collection efficiencies demanded to meet particulate standards, as shown in the test



Sources: EPA, 1973; 1975.

FIGURE 4-7
EFFICIENCIES REQUIRED TO MEET NSPS FOR PARTICULATES AS FUNCTION OF UNCONTROLLED EMISSION RATES

TABLE 4-4

ESTIMATED PARTICULATE CONTROL EFFICIENCY FOR EQUIPMENT USED WITH SECONDARY LEAD FURNACES

Control Device	Furnace Type Applicable	Particulate Control Efficiency, %[a]
Fabric Filter (Baghouse)	Blast	98.4
	Reverberatory	99.2
Dry Cyclone Plus Fabric Filter	Blast	99.0
Wet Cyclone Plus Fabric Filter	Reverberatory	99.7
Settling Chamber Plus Dry Cyclone Plus Fabric Filter	Reverberatory	99.8
Venturi Scrubber Plus Demister	Blast	99.3

[a]Not necessarily efficiencies achieved by BTS.

Source: EPA, 1975.

results and in analysis of rated capabilities of control equipment. However, very high pressure drops are demanded of a venturi scrubber for high efficiencies in removing small particles. For example, a pressure drop of greater than 40 inches WG would be required to achieve 99 percent efficiency with particles less than 0.4 microns such as those emitted by reverberatory furnaces (Soderberg, 1974). Therefore, a pressure drop of up to 100 inches WG should not be surprising (Engineering-Science, 1977).

Studies of the air around secondary lead smelters in Canada showed the suspended lead particles to be relatively large and nonrespirable. The influence of fugitive emissions was suspected. However, comprehensive data are lacking, and it would be unwise to

draw general conclusions from these limited observations (Roberts et al., 1974). Based on physical considerations, it might therefore be expected that the lead content of particulates emitted from a control system would be lower than that on an uncontrolled basis. Generally, the larger particles are easier to trap both in a fabric filter and in a scrubber control device, whereas efficiency of the collector systems tends to decrease with particle size.

Test results on secondary lead furnaces equipped with scrubbers and/or baghouses may support this conjecture (EPA, 1973; Davis, 1973). In six tests conducted on emissions from seven furnaces, the lead emissions represented about 19 percent of the particulate emission rate. This compares with EPA estimates (1977) of 23 percent lead content of uncontrolled emissions. Lead emissions under controlled conditions are discussed further in Section 6.3.

4.4.2 Cost to Industry

The cost of controls for particulate emissions depends not only on the type of system selected but also on operating variables at a given secondary lead smelter.

4.4.2.1 Baghouses. Capital and annual costs for a fabric-filter control system fitted to blast and reverberatory furnaces have been calculated by EPA (1977) on the basis of typical or model furnaces, with some operating parameters specified and others implicitly averaged out. It was found in the analysis forming the basis of these calculations that capital costs for both furnace types were primarily a function of flow rate in actual cubic feet per minute (ACFM) of gas

exiting the furnace. For furnaces with flow rates of between 10,000 and 100,000 ACFM, the capitalization costs were expressed as:

$C = 906\ Q^{0.6}$ (reverberatory furnaces)

$C = 2460\ Q^{0.6}$ (blast furnaces)

where C is expressed in dollars and Q represents flow rate in actual cubic feet per minute. These results are plotted in Figure 4-8.

Capitalization costs comprised equipment, installation, interest during construction, taxes, engineering, and other miscellaneous items including a 20 percent allowance for contingencies (EPA, 1977).

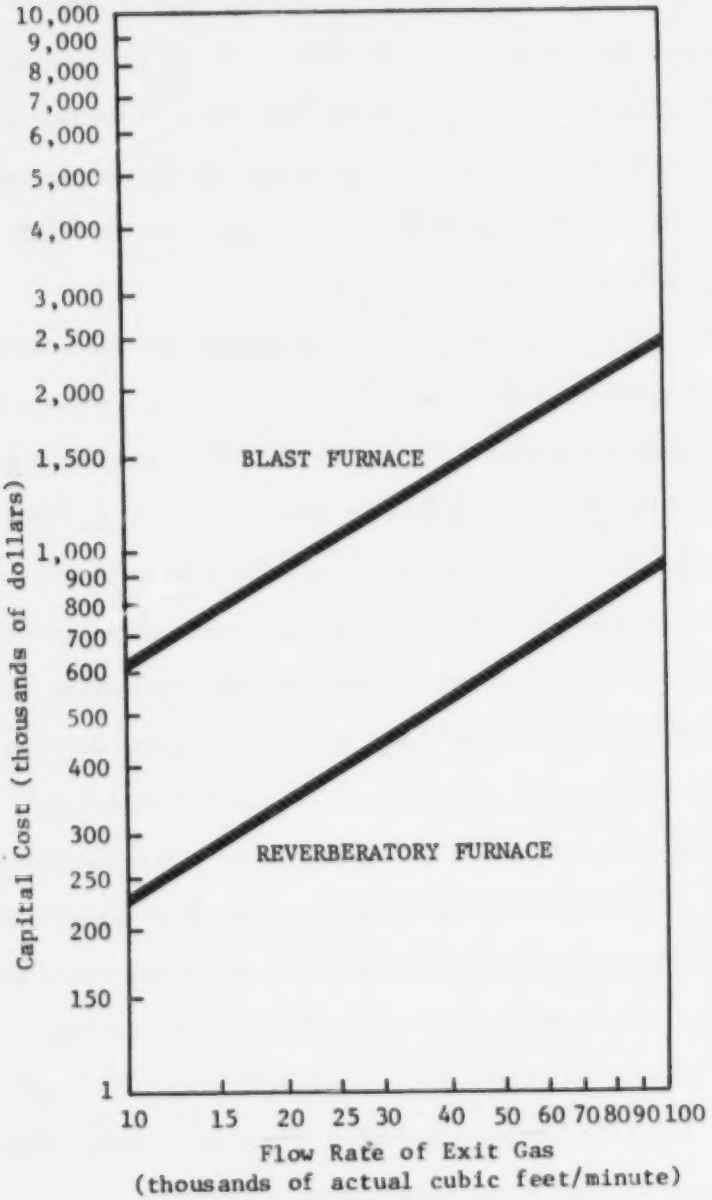
Annualized costs included capital recovery, utilities, operating labor, maintenance, and overhead. These costs were expressed as a function of flow rate and of annual hours of labor. Specifically, annualized costs in dollars were expressed as:

$A = 0.364Q + 19.6H + 236Q^{0.6}$ for reverberatory furnaces

$A = 7.25Q + 642Q^{0.6} + 19.6H$ for blast furnaces

where Q represents flow rate as before and H denotes annual labor hours.

Costs were calculated for reverberatory and blast furnaces with a capacity of 50 tons/day. For the reverberatory furnace an exhaust rate of 33,500 ACFM at 1350°F was assumed and for the blast furnace a rate of 32,000 ACFM at 500°F. These flow rates correspond approximately to about 17,000 and 10,000 dry standard cubic feet per minute (dscfm) depending on the percent of moisture in the gas. For annualized cost it was assumed that 3000 hours of labor were required per year.



Source: EPA, 1977.

FIGURE 4-8
CAPITAL COSTS OF A FABRIC FILTER CONTROL SYSTEM FOR BLAST AND REVERBERATORY FURNACES AS FUNCTIONS OF FLOW RATES

For the 50 ton/day reverberatory furnace, capital costs were calculated by EPA to be $470,000 and annualized costs were $194,000 (mid-1976 dollar values). For the corresponding blast furnace, the capital and annualized costs were much higher--$1.24 million and $615,000, respectively. Credit for recycling the dust estimated to be collected at a value of 5 cents/lb would result in decreasing annualized costs by $141,000 for a reverberatory furnace and $150,000 for a blast furnace (EPA, 1977).

Earlier analyses indicated that the equipment and installation cost of baghouse systems used to control reverberatory furnaces would be higher than that for a blast furnace of the same capacity. A study by the Industrial Gas Cleaning Institute (Hardison et al., 1970) was based on a survey of companies supplying control systems to secondary lead smelters. The figures of this study agree with those of EPA (1973) that rate the reverberatory furnace the more expensive of the two. The Industrial Gas Cleaning Institute (IGCI) study derived costs as a logarithmic function of flow rate in actual cubic feet per minute, which was then equated to a furnace of specified capacity. The relation of flow rate to furnace capacity does not agree with that used in the model plant figures cited earlier from EPA (1977); thus two cost figures, one based on flow rate and the other on furnace capacity, give a range of values for comparison. The IGCI figures are much lower than the 1973 EPA estimates for furnaces of equivalent size. The various estimates are summarized in Table 4-5.

TABLE 4-5

COMPARISON OF COST ESTIMATES FOR CONTROL OF SECONDARY LEAD SMELTERS - FABRIC FILTER SYSTEM (dollars)

Cost	EPA (1977)	IGCI (1970)	EPA (1973)
Reverberatory Furnace			
Capitalization Cost	474,000	168,000-260,000	188,000
Annual Operating & Maintenance Costs[a]	-	9,100-14,250	-
Annualized Costs[b]	53,000	-	51,000
Blast Furnace			
Capitalization Costs	1,240,000	61,000-82,000	157,000
Annual Operating & Maintenance Costs	-	3,800-6,000	-
Total Annualized Costs	465,000	-	21,000

[a]EPA operating and maintenance costs are included in total annualized costs.
[b]Includes credit from recycled dust (deducted from total annualized costs).

4.4.2.2 Venturi Scrubbers. The most precise recent cost estimates of venturi scrubber control systems were developed by EPA (1978). Computer modeling techniques were used to calculate costs for both blast and reverberatory furnaces as functions of flow rates and efficiency in particulate removal. Parametric input was obtained for cost factors for the various system components (including installation) developed in a study under contract to EPA (Kinkley and Neveril,

1976). On the basis of 99.5 percent efficiency in particulate removal, capitalization costs for blast and reverberatory furnaces of 50-ton/day capacity can be estimated at about $775,000 and $580,000, respectively (in 1976 dollars). These costs are based on exit rates of furnace gas of about 32,000 and 33,500 ACFM, respectively, so as to derive estimates comparable to those of the model furnaces for which baghouse costs were developed by EPA (1977).

These cost estimates for venturi scrubbers may be compared with those from other sources, as shown in Table 4-6. This table expresses costs for 50 ton/day furnaces in thousands of 1978 dollars. Flow rates were used to scale costs not estimated for secondary lead smelters. It can be seen that the above EPA estimates for blast and reverberatory furnaces bracket the estimate of about $640,000 from a control equipment manufacturer. Differentiation between furnace types was not feasible for this estimate. Estimates developed earlier are much lower, even after applying inflation factors for increases in costs of machinery and equipment (U.S. Department of Commerce, Bureau of the Census, 1976).

The IGCI estimated costs for a high-efficiency venturi scrubber are about $137,000 for a 50 ton/day blast furnace, assuming only 14,700 ACFM. With an assumed flow of 32,000 ACFM, the corresponding IGCI costs increase to about $175,000. For a reverberatory furnace, the cost estimates on a 50 ton/day and 33,500 ACFM basis are, respectively, about $103,000 and $115,000. These figures agree with EPA (1978) estimates in being higher for a blast furnace and lower for a

TABLE 4-6

COMPARISON OF COST ESTIMATES FOR CONTROL OF
SECONDARY LEAD SMELTERS WITH VENTURI SCRUBBERS
($ thousands)

Source	EPA (1978) Reverberatory	Blast	EPA (1973) Reverberatory	Blast	IGCI (1970) Hardison et al. (1970) Reverbatory	Blast	Manufacturer's Estimate(1978)[a] Combustion Equipment Associates (1978) (Not distinguished)
Capitalization Cost[b]	580	775	125	123	115	175	640
1978 dollars	669	895	202	199	184	280	640
Annual Operating & Maintenance Costs	N/A		N/A		1	1	N/A
1978 dollars	N/A		N/A		1.6	1.6	N/A
Total Annualized Costs	N/A		36	80	N/A		N/A
1978 dollars	234	313	58	128	N/A		N/A
Assuming Credit for Recycled Fines 1978 dollars	152	226	N/A		N/A		N/A

[a]Based on conversion from estimate in dollars/megawatt, assuming a basis of flow rate for smelters that corresponds to a 9-MW power plant; type of furnace not distinguished.
[b]As provided by source (i.e., before conversion to 1978 dollars).

reverberatory furnace than the EPA (1973) estimates for venturi scrubber capitalization costs. Direct comparison of estimates from various sources is difficult because of different assumptions regarding costs. It is not known what items were included or what efficiency in particulate control was assumed.

In estimating fixed annual costs for control systems using venturi scrubbers to control lead emissions from various sources, EPA recently used as a general rate 20.28 percent (including taxes) of total capital investment (EPA, 1977). Operating and maintenance costs are estimated to range generally between 8 and 18 percent of total capital investment, with 13 percent an average figure although very high percentages of up to 40 percent are noted (Kinkley and Neveril, 1976). On this basis, a rate of 35 percent may be assumed for total annualized costs. These would accordingly run about $234,000 each year for a reverberatory furnace and about $313,000 for a blast furnace. Total annualized costs for the earlier EPA estimates and annual operating and maintenance costs as estimated by IGCI are also shown in Table 4-6.

EPA (1975) originally estimated the value of recycled lead-bearing dust from venturi scrubbers to be half that from fabric filters. Applying this factor to the credit for recycled dust from baghouses of $150,000 for a blast and $141,000 for reverberatory furnaces (EPA, 1977) and escalating the value to 1978 dollars, total annualized costs would be reduced to about $226,000 for a blast furnace and $152,000 for a reverberatory furnace as shown in Table 4-6.

A significant feature that emerges from the range of cost estimates is the effect of annualized costs of controls per ton of product. Originally, EPA (1973) estimated the annual cost per ton of lead produced to be $1.65 for reverberatory furnaces and $4.05 for blast furnaces. Both figures were based on fabric filter control; with venturi scrubbers, the cost per ton estimates increased to $2.86 and $6.40, respectively. A representative 50 ton/day furnace was assumed for the estimates. These early estimates appear to have been too optimistic. From the Bureau of Mines statistics previously considered in Section 4.1.1, the average annual production of a secondary lead plant of about 6000 tons is close to the average output of 6875 tons/year of the 24 smelters of the second-largest set of producers, which produce approximately 50 tons/day (Table 4-2). The two largest producers operate smelters that are larger than 50 tons/day; whereas small plants operate smelters of much lower capacity. The average output in any year varies, but taking the 1975 figure of 6875 tons as a basis for a representative 50 ton/day smelter, annualized costs can be seen in Table 4-7. The costs as percentage of the price per ton of lead product are based on escalating the average 1976 price to 1978 dollars by an assumed inflation rate of 7.5 percent per year, which is about the increase in 1976 price per ton of lead over that for 1975.

It may be reasonably assumed that new furnaces will be larger than the previous average sizes. Information available to the Bureau

TABLE 4-7

ESTIMATED COSTS OF CONTROL (ANNUALIZED BASIS)
(1978 dollars/ton of lead)

Cost	Reverberatory Furnace		Blast Furnace	
	Baghouse	Venturi Scrubber	Baghouse	Venturi Scrubber
Total Annualized Costs ($000)	61	152	536	226
Average Cost (Dollars/Ton)	9	22	78	33
Value of Lead Product (%) ($534/ton)	2	4	14	6

of Mines (1978) indicates furnaces which have or will come on line in the 1977-1979 period to range from 27,000 up to 70,000 ton/year capacity and a daily capacity of more than 100 tons.

However, it is difficult to convert EPA estimates to larger furnaces or to estimate the costs involved on a basis of dollars per ton of product. On the one hand, estimates provided by IGCI (Hardison et al., 1970) were based on flow rates as a linear function of size of furnace. Therefore, no economy of scale is achieved and the cost of a specific control system per ton of product for a given type of furnace does not vary. On the other hand, flow rates as used in more recent calculations by EPA (1978) represent a second degree function of furnace capacity from which significant economies of scale result.

The annual production of these larger furnaces is unknown. It is reasonable to relate control costs for a 50-ton day furnace to average

production figures, because such a furnace can be taken as typical of existing plants. However, estimates for new furnaces twice as large or larger would have to be based on predictions as to future annual production and the relative share of the market that these newer and bigger plants will capture. The very limited data available will not support precise calculations but approximations are possible; these indicate the range of reduction in control costs per ton of product that result from estimates based on much larger furnaces.

Calculations by EPA (1978) for reverberatory furnaces equipped with venturi scrubbers reflect an increase of under 15 percent in flow rate for a furnace twice the capacity of that previously taken to represent a 50-ton day furnace. The increase in capitalization costs is a relatively modest 7 percent. For blast furnaces, an increase in flow rate of approximately 50 percent is postulated when the furnace capacity is doubled. The increase in capitalization costs is about 32 percent.

These increases in assumed flow rate may also be applied to furnaces equipped with fabric filters. The estimated flow rates can then be used to derive new capitalization estimates from the formulas used by EPA (1977) as previously cited. (These estimates may also be read from the graphs in Figure 4-8.) On this basis, the blast furnace with a capacity of 100 tons or more per day would use a flow rate of about 50,000 ACFM, and the reverberatory furnace a rate of about 40,000. Applying these approximations to the cost functions

previously cited results in estimates of about $1.62 million and $520,000 for blast and reverbatory furnaces, respectively. These represent relatively modest increases of about 31 and 11 percent, respectively, in the cost of controls for furnaces of more than double the original size.

When these percentages are applied to the estimated annualized costs for furnaces of the respective types of furnaces and control systems, the results are:

Furnace	Annualized Costs (Thousands of 1978 Dollars)
Reverberatory furnace, fabric filter	68
Reverberatory furnace, venturi scrubber	163
Blast furnace, fabric filter	702
Blast reverberatory furnace, venturi scrubber	298

Relating these costs to furnace output requires similar assumptions to those already made. In the absence of more specific data, it is not unreasonable to assume that the production of these furnaces will be approximately twice the annual output of the smaller typical furnaces half their size. On the basis of 13,000 tons of lead/year, the cost of controls per ton would be about $54 and $23 for blast furnaces with fabric filter and venturi scrubber, respectively. Corresponding figures for reverberatory furnaces would be about $5 and $13/ton.

While these estimates necessarily remain conjectural, they indicate the possibility that the increase in price of a ton of secondary lead necessary to recover the increase cost of controls per ton of lead product for the furnaces subject to NSPS may be on the order of 60 to 70 percent of the estimates shown in Table 4-7.

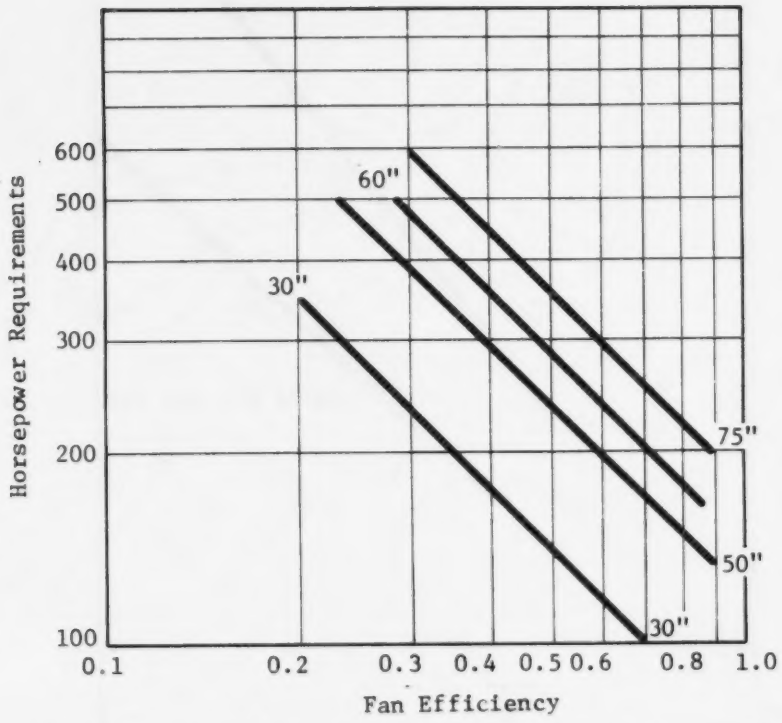
Some of the cost increase due to controls might be absorbed in lower prices paid for lead scrap, but a substantial part or all of the cost will be passed to the consumer. Figures for the entire non-ferrous metal industry showed the net income after taxes to be in the range of 4 percent for 1976-77 (Levine, 1978). These averages include large primary producers, as well as secondary smelters. Information on the secondary lead industry alone is not available. It is certain that many small smelters will earn a smaller net income and could face severe difficulties in modifying or reconstructing a furnace.

4.5 Energy and Other Resource Requirements

Requirements for additional consumption of energy and other resources are very small for fabric filter control systems that operate at a nominal pressure drop of between 3 to 7 inches water gauge, with an average of 4 inches (Engineering-Science, Inc., 1977; Soderberg, 1974). Additional requirements imposed by the use of venturi scrubbers may be calculated in terms of horsepower necessary to provide high pressure drops and flow of water used in wetting and separating the particles.

Horsepower requirements as a function of pressure drop and fan efficiency are shown in Figure 4-9. Results in terms of additional energy and fuel consumption are shown in Figure 4-10, assuming that a plant operates on the average for 2800 hr/yr. This figure is based on the average annual plant output of 5725 tons and a typical capacity of 50 tons/day. Further assumptions have been made regarding the amount of Btu as heat input required per kilowatt-hour (1 kW-hr represents 0.7457 hp-hr) as shown in the figure. The fuel requirements are presented in terms of barrels of oil equivalent to provide the necessary heat input, on the assumption of 6 million Btu per barrel of oil. The results represent a wide range because of variations possible in both fan efficiencies and pressure drop. However, the fuel requirements are on the order of 1000 barrels of oil equivalent per plant per year.

Water requirements may be estimated on the basis of a typical plant with a gas flow rate of 15,000 cfm. Various ratios of water in gallons per minute to flow rate in thousands of cubic feet per minute may be employed in wet scrubber systems from less than one to as high as 20 (American Air Filter Company, Inc., 1978). Typical rates of about 3 gal/min for each 1000 cfm of gas flow have been reported for venturi scrubbers (Danielson, 1973; Soderberg, 1974). On this basis the typical plant may be assumed to use about 2700 gallons of water per hour or about 7.56 million gallons in a year's operation as calculated above. The recycling rate for scrubber water is high. Based on the assumption that 90 percent or more of the water would be recycled, annual consumption is about 750,000 gal/plant.



Lines Represent Pressure Drop in Inches, Water Gauge.

Sources: Salisbury, 1967; Engineering-Sciences, Inc., 1977.

FIGURE 4-9
HORSEPOWER REQUIREMENTS FOR VENTURI SCRUBBER AS A FUNCTION OF FAN EFFICIENCY AND PRESSURE DROP

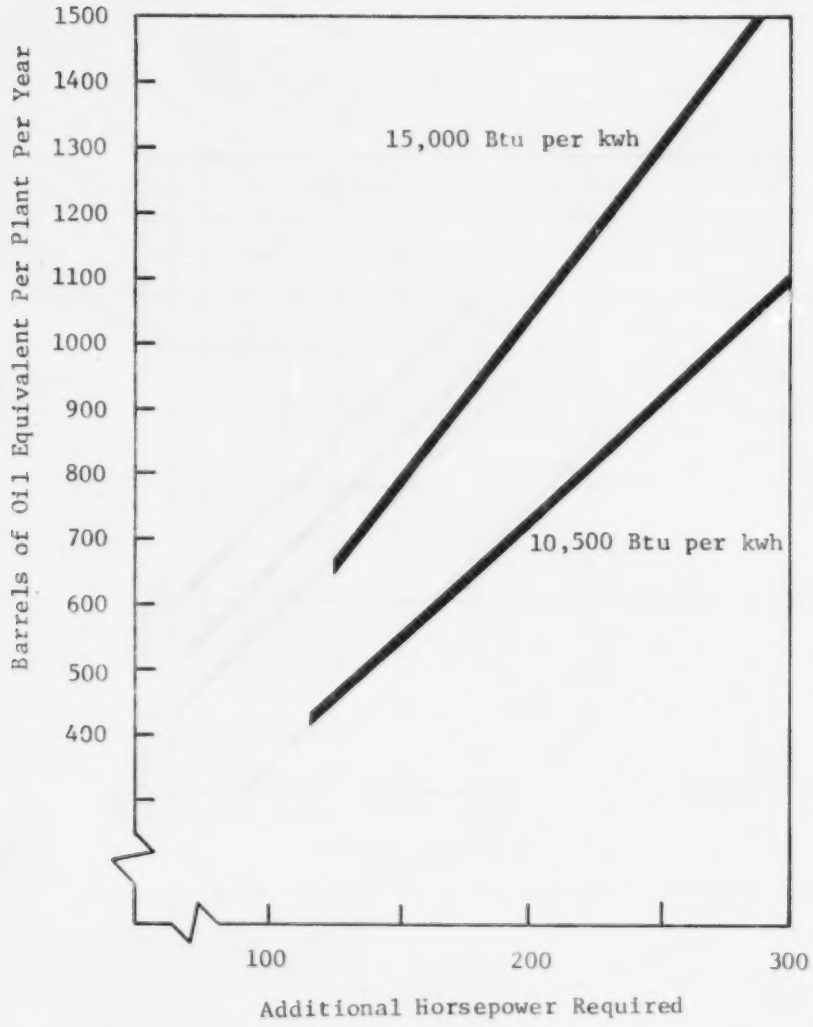


FIGURE 4-10
FUEL REQUIREMENT FOR VENTURI SCRUBBERS

4.6 Environmental Effects of NSPS

4.6.1 Estimated Particulate Reduction

Prior to promulgation of current NSPS for smelters, EPA (1973) estimated that the secondary lead industry was approximately 90 percent controlled. On this basis the particulate output of an average plant may be estimated as 10 percent of the uncontrolled rate. Uncontrolled emission rates in Table 4-3 are based on pounds per ton of metal charged to the furnace. Using an average figure of 70 percent lead product recovered from the metallic input, these values have been adjusted (as used in Table 4-8) to facilitate conversion to annual output through use of average rates. It was assumed that each new plant would produce on the average 6000 tons of lead per year (a slightly higher figure than the 1975 average obtained from Bureau of

TABLE 4-8

ESTIMATED ANNUAL REDUCTION OF PARTICULATES FROM NSPS

	Blast Furnace	Reverberatory Furnace
Average particulate emissions per plant (lb/ton of product)[a]	276	210
Without NSPS (90% control)	28	21
With NSPS (99.3% control)	2	1
Net reduction per plant (lb/ton of product)	26	20
Annual average reduction per plant (tons)	78	60

[a]Single value rates as estimated by EPA (1975) multiplied by 1.43 to convert lb/ton of lead product.

Mines statistics).* A conservative estimate of 99.3 percent efficiency was used to calculate particulate emissions under NSPS. It was further assumed that all lead would require smelting in either a blast or reverberatory furnace with any refining or alloying in pot furnaces additional. (Pot furnaces have negligible emissions and are not subject to particulate control under NSPS rates on an uncontrolled basis.)

As shown in Table 4-8, the average annual reduction per plant is 78 tons of particulates for blast furnaces and 60 tons for reverberatory furnaces. Assuming an approximately equal mix between the two figures and rounding off the average value to 70 tons annually, the average can be applied to the number of plants coming under NSPS in any one year. The EPA (1973) estimate of 2 plants coming on line each year results in a value of 140 tons of emission reduction. This figure estimates the reduction in any one year from new and modified plants subject to NSPS. If a constant growth rate is assumed for each of the 4 years during which the NSPS have been in effect, the total reduction would be 10 times this figure or nearly 1,400 tons of particulates.

4.6.2 Estimated Reduction in Lead Emissions

The secondary lead industry is not one of the prime sources of lead emissions; its annual output is estimated to be only about one-third that of primary production of lead. In total tons of lead

*Future plants are likely to be about twice as large, so that annual reductions for 1978 and later may be double those shown in Table 4-8.

emitted, the secondary smelting industry ranks behind copper, various iron and steel processes, gasoline additives, oil-fired utilities and municipal incinerators. A survey of plants that produced approximately 90 percent of all secondary lead in 1970 showed an average factor of lead emissions to the atmosphere of 0.7 lb/ton of product (Davis, 1973; MITRE Corporation, 1977).

Quantitative data are limited on the emission rate of lead from control systems meeting NSPS for particulates from secondary lead smelters. Limited test data from seven furnaces cited in Section 4.4.1 indicate that baghouses and/or venturi scrubbers may reduce the rate of output (from the overall industry average of 0.7 lb/ton) by one to two orders of magnitude. Lead emissions reported from the plants tested ranged from about 0.009 to 0.0846 lb/ton; five of the tests resulted in emissions below 0.04 lb/ton (EPA, 1973). Using the figure of 0.05 lb/ton as a conservative estimate,* the reductions in lead emissions attributable to NSPS may be calculated for plants subject to these standards in the same way as was done for particulates in the preceding section. The results are summarized in Table 4-9.

The figures in Table 4-9 do not coincide with results that would be obtained by applying to the estimates of reduced particulate emissions (as given in Table 4-8) factors for the average concentration of lead particles. On the basis of 23 percent lead content of

*This estimate correlates well with that obtained from EPA (1977) estimates of 99.92 efficiency for capture of lead emissions with baghouses as considered in Section 6.3.

TABLE 4-9

ESTIMATED TOTAL REDUCTIONS IN LEAD EMISSIONS FROM NSPS

Average emissions per plant	
Uncontrolled	53-56 lb/ton
Without NSPS	0.70 lb/ton
With NSPS	0.05 lb/ton
Net reduction	0.65 lb/ton
Average annual reduction per plant	3900 lb/1.95 tons
Annual reduction for plants newly subject in 1 yr	27.30 tons
Estimated cumulative reduction 1974 - 1978	273.0 tons

particulate emissions and using the estimates of Table 4-8, the reductions in lead emissions would increase by a factor of about eight over the results shown in Table 4-9. Several explanations for the discrepancy are possible:

- The degree of particulate control in the absence of NSPS assumed for the secondary lead industry is too low, so that the net reduction in particulate emissions is overestimated in Table 4-8.
- The estimate of 23 percent lead in uncontrolled particulate emissions does not apply to the outlet of a control system, which actually traps a disproportionately high amount of lead-bearing particles.
- The average of 0.7 lb of lead emitted per ton of product is inaccurate for the secondary lead industry as a whole so that the lead emissions in the absence of NSPS are actually higher than reported. Comparing the value of 0.7 lb/ton with the estimate of uncontrolled lead emissions on the basis of 23 percent of particulates or about 55 lb of lead per ton of product implies an efficiency of about 98 percent in control of lead.

In the absence of more definitive data, particularly on lead emission rates both controlled and uncontrolled (discussed further in Section 6), the inconsistency cannot be resolved.

5.0 INDICATIONS FROM TEST RESULTS

5.1 Test Coverage in Regions

MITRE/Metrek surveyed secondary lead smelters in the 10 EPA regions to obtain NSPS compliance data and emission control technology information (Table 5-1). Results of one test from Region II and three tests from Region IV were made available. No compliance data were available from the other regions. A few other tests were conducted, but reports were not supplied.

All tests were found to be in compliance with the particulate standard. Two of these tests (Region IV) were also found to be in compliance with the opacity standard. Test results for opacity were not reported from the other plants.

The process equipment affected by the standards varied among the plants tested. The plant tested in Region II reported a facility subject to NSPS consisting of three pot furnaces exhausting through one stack. Region IV reported process equipment that consisted of a reverberatory furnace at one plant and a blast furnace at another. Furnace type for the third was not reported. Whether the plants tested were new or modified sources is unknown.

Control technology for the pot furnaces in the plant in Region II is unknown. The technology for the reverberatory furnace in Region IV was reported to be afterburners and a melting chamber;* the technology for the other furnaces was reported to be a baghouse.

*At this time (December 1978), clarification of this surprising report has not been provided.

TABLE 5-1

MITRE/METREK SURVEY OF NSPS TEST DATA FROM REGIONS II AND IV[a]

Region and Test No.	Process Equipment	Pollutants		Control Technology
		Particulates (gr/dscf)	Opacity (%)	
II-1[a]	3 pot furnaces exhausting through one stack	0.0013	-	Unknown
IV-1[a]	Reverberatory furnace	0.015	<10	Afterburners, melting chamber
IV-2[a]	Blast furnaces	0.0135	0	Baghouse
IV-3[b]	Unknown	0.0106	-	Baghouse

[a]No tests submitted from the other eight regions. MITRE Corporation, 1978.

[b]EPA, 1979.

5.2 Test Data

Available test data are too limited to be considered as adding anything new to results reported prior to promulgation of NSPS. The relevant tests (pot furnaces are not subject to control of particulates under NSPS) should be considered as three more data points that may be added to the nine tests conducted by EPA and the Los Angeles County Pollution District. In all of these tests reported for plants controlled by baghouses and/or venturi scrubbers, particulate emissions averaged less than 0.022 gr/dcsf (EPA, 1973; Engineering-Science, Inc., 1977).

6.0 ANALYSIS OF POSSIBLE REVISIONS TO NSPS

6.1 Industry Trends

General trends of the secondary lead industry discussed in Section 4 included the gradual rise in annual output, increased secondary lead production with a decrease in the number of plants, and changes in the pattern of lead consumption. An important technologic development is the emergence of a new battery for vehicles which is relatively maintenance free. This battery requires lead alloyed with only one-half to one-third the antimony content previously used. A higher heat rate is applied in resmelting the scrap batteries and in producing a lead that is virtually free of antimony. As a result, the quantity of vapors and particulates emitted from the furnace with a given charge of material may be increased, although quantitative data on the effects are lacking. The development of secondary lead with very high purity tends to increase interchangeability between the recycled metal and that produced from virgin ore. In some instances, secondary lead is produced that is purer than the primary product. The competitive position of secondary lead is apparently becoming stronger, although the relative share of the market remains near the 50 percent level subject to minor fluctuations each year (Bureau of Mines, 1978).

The real price of lead has been decreasing steadily since 1950. In terms of constant 1976 dollars, the price has declined by about 27 percent since 1954 and about 10 percent between 1974 and 1976. Thus, the profit margin or net annual income of the industry as a whole is

continuing to decrease at a time when heavy costs are being required to control pollutants. In production of primary lead, capital expenditures have been particularly high (Bureau of Mines, 1977; 1978). Thus, it appears that pollution control has not degraded the competitive position of secondary lead.

Production of lead from both primary and secondary sources is expected to grow by about 50 percent between 1976 and 2000. Changes in demand patterns including attrition of the tetraethyl lead market and the substitution of other materials for such uses as paints, cable covering, calking, and some types of containers are expected to slow the rate of, but not prevent increases in, lead production. Average annual increase in demand for lead from 1967 to 1976 was about 3 percent. A 50 percent increase by 2000 implies an annual growth rate of slightly under 2 percent. Bureau of Mines figures project that the demand for lead in the year 2000 will be from 1.08 to 2.46 times the 1976 consumption of about 1.5 million tons. An estimated total demand of 2.33 million tons is deemed by the Bureau of Mines to be the most probable projection. The demand for lead in gasoline additives is projected to decrease to about one-third of its 1976 level, although a decrease by a factor of as much as six is possible. Attrition of this market is expected to be compensated by varying increases in all other end uses. Demand for lead for other transportation purposes is expected to more than double. The fraction of the market represented by use of lead in paints and for electrical purposes will increase

about 20 percent over that in 1976. End uses for other construction purposes, in ammunition, and for miscellaneous products are seen as changing less than 1 percent from their respective 1976 market percentages (Fine et al., 1973; Bureau of Mines, 1977).

6.2 Review of Current NSPS

Little substantive data on current NSPS for opacity and particulates from secondary lead smelters can be added to that reported by EPA (1973) at the time the standards were proposed. Standards of 0.022 gr/dscf for particulate emissions and 20 percent or less in opacity (10 percent for pot furnaces) are being met. No failure in meeting standards has been reported in information available to the present study. Hence, there is no basis for relaxing these standards.

Test results after 1973 are too limited to provide any foundation for inference as to whether efficiency of control systems has improved enough to support more stringent standards. Fabric filters and high-efficiency venturi scrubbers still represent best technologic system of control. Examination of estimated inlet loadings to collector systems indicates that control efficiencies well in excess of 99.5 percent are required. Efficiencies in this range are reported in the literature, and EPA (1977) has estimated overall collection efficiencies of 99.91 and 99.09 percent from the front half and the total train, respectively, for secondary lead blast furnaces equipped with baghouses. Specific test data are, however, lacking by which to fix the performance of control systems over the range of operating

conditions that may be encountered and, hence, to support a basis for a more stringent level of control for particulate emissions.

In regard to opacity, less quantitative data are available than for particulates. It is known that optical transmittance can range widely in relation to mass concentration of particulate matter. On physical grounds and from analogy with industries where more test data exist, one might conjecture that an opacity reading of considerably less than 20 percent be associated with the NSPS for particulates of 0.022 gr/dscf.

6.3 Lead

6.3.1 Emission Rates

EPA (1975) estimates the uncontrolled emission rate for lead from blast and reverberatory furnaces as 56 and 53 lb/ton of product, respectively, or about 23 percent of the particulate emissions. Somewhat higher rates were reported in a recent study (details are not yet available) and the issue remains in doubt. These are high per unit when compared with storage battery manufacturing (17.7 kg/1000 batteries), lead glass (15 lb/ton of product), iron and steel production, and various processes that account for high percentages of annual lead emissions as tabulated by EPA (1977). However, EPA estimates the secondary lead industry to be about 95 percent controlled and the 1975 total output of lead emissions from secondary smelters to be about 830 tons. This compares with over 18,000 tons expected at the uncontrolled rate from the production of 658,500 tons of secondary lead in 1975.

6.3.2 Control Effectiveness

Controls for lead from secondary furnaces are the same as those for particulates. The technique consists of capturing the lead-bearing particles in a baghouse or removing them in a high efficiency wet scrubber. EPA deems the baghouse to be the most effective control technique and estimates its efficiency in removing lead emissions to be as high as 99.92 percent, based on total-train sampling. This estimate would give a controlled emission rate of about 0.0448 lb/ton of lead, or an emission rate of 2.24 lb/day for a typical 50 ton/day plant. The average plant production rate of about 6000 tons annually would result in about 270 lb/yr, or about 0.13 tons/year.

The important question in regard to control of lead emissions is whether the lead is captured in the form of lead-bearing particles at the same rate as particulates generally or whether higher fractions of the lead escape as smaller particles or possibly in vaporized form. If the captured particles contain 23 percent lead (i.e., the same percentage as estimated for uncontrolled emissions) then a 50 ton/day plant meeting the particulate standards at 0.022 gr/dscf would release about 2.8 lb/hr of particulates (based on a flow rate of 15,000 dscf) of which the lead content would be (at 23 percent) about 0.65 lb/hr or slightly over 0.3 lb/ton.

Results in control of lead emissions were recently reported by the Chicago Department of Environmental Control (Petkus et al., 1974). A survey of 11 controlled smelters producing some 6600 tons of lead in

a year revealed lead emissions at the rate of approximately 1 lb/million lb (500 tons) of product (controlled emission rate of 0.002 lb/ton of product).

Very little basic data from tests on controlled lead emission rates are available. However, six tests conducted before 1973 showed lead emissions from plants controlled by baghouses and/or venturi scrubbers to be slightly less than 23 percent of the particulate rate or about 19 percent on the average.

Sublimation of lead particles might be conjectured at the very high temperatures at which the stack gas leaves the reverberatory furnace (up to 1350°F) or in the afterburner of the blast furnace. However, gas must be cooled to 500°F or less before entering a baghouse to avoid damage to the filter fabric. With venturi scrubbers, the water quench necessarily succeeds also in reducing the temperature of the gas. Thus, the likelihood of vaporized lead escaping a control system is much less than the likelihood of sublimation within a furnace or afterburner. Such particles escaping the collector would tend to be smaller than 1 micron.

No test data exist for comparing baghouse content of lead with the results of Method 5 tests of emissions from fabric filters. No materials balance is thus possible to account comprehensively for where lead emissions from the smelting furnaces finally appear. Available evidence is consistent, however, in indicating that the ratio of lead to particulate emissions from controlled furnaces is no

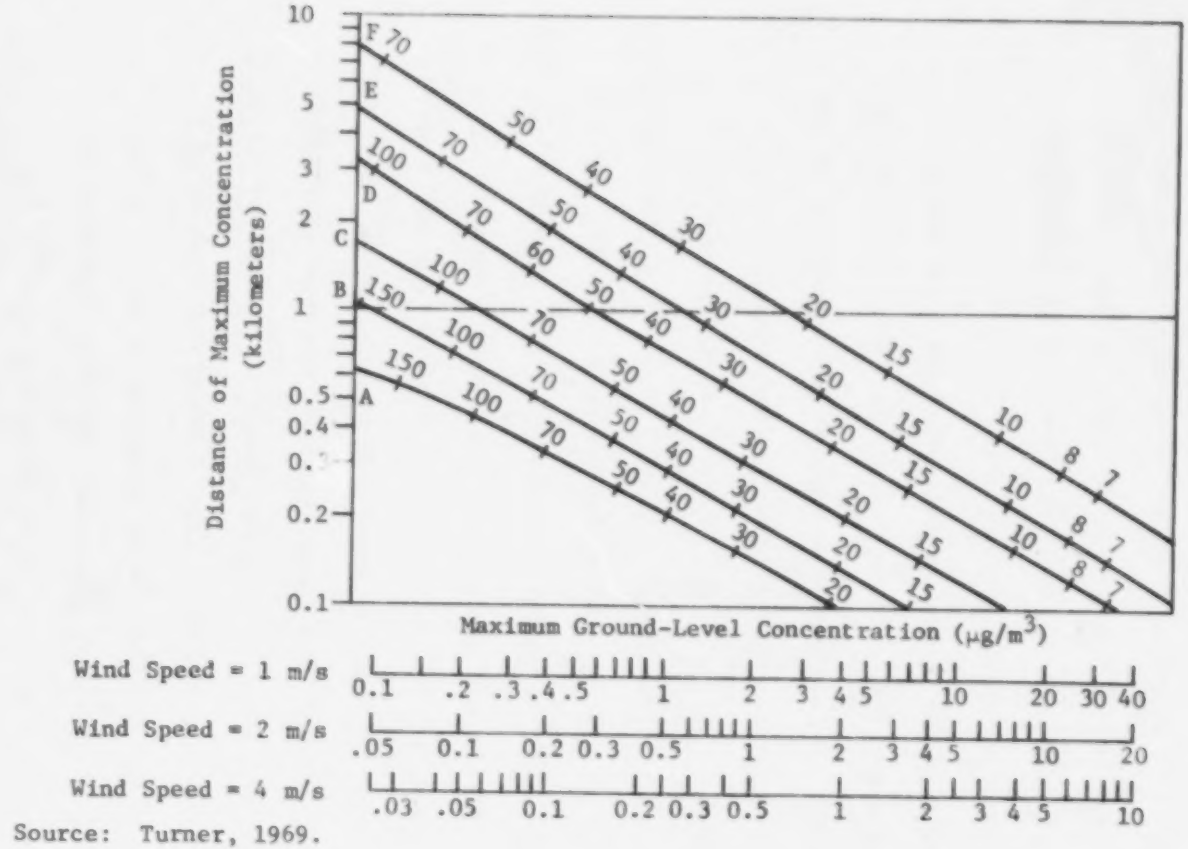
higher than the ratio for uncontrolled rates (23 percent). Further, the estimate of 0.0448 lb/ton of product based on 99.92 percent baghouse efficiency appears as a reasonable, and even conservative, estimate for a well-controlled furnace.

Ambient standards for lead have now been promulgated by EPA. Based on modeling results, EPA has estimated (Scruggs, 1977) that for each ton of lead product, the lead concentration nearby will be 8.69×10^{-5} $\mu g/m^3$. The maximum downwind concentration average over a year was estimated to be about 0.0105 $\mu g/m^3$ for each ton of lead emitted by a plant. Although much higher values have been recorded near secondary smelters, they are unlikely to be observed as a result of stack emissions from well-controlled furnaces. Tests near a smelter in Texas at a range of about 60 to 300 meters distant showed air concentrations from 3.3 $\mu g/m^3$ to as high as 11.6 $\mu g/m^3$ (Texas Air Control Board, 1974). Data are not available as to the degree of control practiced at this site. Roberts et al. (1974) report lead concentrations in suspended particles at about 200 m from two Canadian smelters in the range from 1 to 5.3 $\mu g/m^3$. These two Canadian furnaces were estimated to have emitted over 33,000 and 66,000 lb of lead per year. Such lead emissions are more than two orders of magnitude greater than estimates previously noted for stack emissions from an average 6000 tons of lead per year furnace; they would not be approached by well-controlled furnaces of much greater capacity.

Figure 6-1 shows the estimated maximum downwind concentrations from the typical 50 ton/day furnace and the distances at which these would be experienced for different meteorological stability conditions as established from calculations by the U.S. Public Health Service (Turner, 1969). Results are based on a 3-minute sampling time. These results will vary with topographic and architectural conditions that prevail at specific furnace locations. However, levels of 2 $\mu g/m^3$ would be expected from the estimated emission rate for a controlled 50 ton/day furnace only under exceptional windspeed conditions. With production and output rates up to four times greater, maximum concentrations of 2 $\mu g/m^3$ would not be expected even with moderate wind conditions of 4 m/s (about 8 knots) or greater. For a 24-hour average, the estimated level decreases to 36 percent of the 3-minute sampling value (shown in Figure 6-1). Thus, a 3-minute level of 5.56 $\mu g/m^3$ corresponds to a 24-hour average of 2 $\mu g/m^3$.

6.3.3 Fugitive Emissions

Besides the material discharged through the stack of a secondary lead furnace, smoke and dust particles may be emitted into the atmosphere in and around a plant from other operations. Some of these emissions may be process-related, e.g., when fumes escape from the hoods provided around potential outlet points of a furnace. Others, which may be termed site related, result from auxiliary operations outside the plant. The term fugitive emissions is often limited to



Source: Turner, 1969.

FIGURE 6-1
MAXIMUM GROUND-LEVEL CONCENTRATION OF LEAD PARTICLES IN AIR AND DISTANCE FROM STACK

process-related emissions, but usage in the literature is divided, with some writers applying the term both to smoke and fumes escaping from the smelting process and to windblown dust from storage and handling procedures. The important point is that both potential sources can contribute significantly to pollution. Both will be discussed in the present section on fugitive emissions with a distinction made between process- and site-related emissions.

No fugitive emission points, whether related to processing or to auxiliary operations at the site, are currently subject to specific control under NSPS for secondary lead smelters. In some situations, fugitive emissions may be high. The high concentration of lead, particularly in the soil, close to two Toronto smelters was largely ascribed by Canadian investigators to "low-level, dust-producing operations rather than. . .stack fumes" (Roberts et al., 1974). In extreme situations, fugitive particulate emissions from processing may amount to over 15 lb/ton of charge from reverberatory furnaces and as much as 12 lb/ton from blast furnaces. While these rates are much lower than uncontrolled emission rates from furnace stacks, they are also substantially higher than rates achieved under NSPS controls. Lead and iron scrap burning may produce from 1 to 2 lb/ton of scrap. Other potential sources include storage, loading and transfer of material, as well as handling of dust collected by control systems (EPA, 1977). It is reportedly common for baghouse catches to be stored in open piles at a plant yard until enough material has

accumulated for charging to a reverberatory furnace (EPA, 1978b). Experimental data are lacking on the extent to which fugitive emissions at secondary lead smelters subject to NSPS control actually occur, either from process-related operations or from auxiliary operations at the site. On the one hand, several factors would be expected to minimize such emissions at well-regulated plants.

Hooding of all points of potential emissions in the smelting process and venting of the air to the control system along with gas from the furnace is intended to prevent significant escape of lead particles or other particulate matter from the collector device. It is in the economic interests of an owner/operator to prevent fugitive emissions during smelting to avoid loss of fines valuable for their lead content, as well as to protect worker health and efficiency. The sound engineering practices dictated by these considerations to prevent such fugitive emissions are prescribed in regulations of the Occupational Health and Safety Administration, which note specifically the need for enclosing potential sources by hooding. Accidental leaks in hooding and ventlines can be minimized by adequate maintenance practice.

However, several variables can affect the discharge of fugitive emissions during smelting and can negate preventive measures. These include process aberrations, differences in raw materials, and variations in operating parameters such as blast air rates. Data on the effects of these variables are not available. Where particulates

escape into the plant area adjacent to the smelting operation, some release to the outside is almost inevitable as a result of normal ingress and egress. Monitoring of the atmosphere adjacent to secondary lead smelters has on occasion uncovered unacceptable concentrations of lead which may reflect fugitive emissions. At least one instance has been reported in which a smelter was required to be sealed, with all air inside the plant vented to the control system (EPA, 1978).

The role of fugitive emissions in the high lead concentrations observed near Texas smelters (previously cited in Section 6.3.2) is unknown. The relative contributions of process- and site-related sources are also unknown for the lead levels in the atmosphere and soil as reported in the Canadian investigations. Assuming that control of fugitive emissions through hooding and venting to the control system achieves a level of reduction over uncontrolled emissions which is comparable to that provided for furnace gas, less than 0.01 lb of particulates/ton of lead product would be expected from processing operations, or a maximum of about 60 lb/yr for each plant. However, data from tests and observations on which to confirm or modify this assumption are not available.

Significant improvements in the technology of controlling fugitive emissions from both process- and site-related operations in secondary smelting of lead have recently been reported in Denmark. The methodology uses improved furnaces that minimize the escape of dusts

during smelting and also enable baghouse contents to be recharged as collected, thereby eliminating the accumulation of these fines in storage piles where they are subject to transport into the environment. Specialized waste management and housekeeping procedures are used in conjunction with the furnaces to reduce the opportunity for emissions from storage of raw materials and other sources on site. The technology has been investigated by the EPA Industrial Environmental Research Laboratory in Cincinnati in connection with the National Institute of Occupational Safety and Health (NIOSH). Testing of the furnaces has been conducted under the joint auspices of EPA and NIOSH at a plant in Denmark. Initial reports indicate the technology as having high potential for application in reducing fugitive emissions from secondary lead smelters in the U.S. (EPA, 1978d).

6.4 Sulfur Dioxide

6.4.1 Emission Rates

The rate of uncontrolled emissions of SO_2 from secondary lead smelters has been estimated by EPA (1975) to be approximately half that of particulates. While the estimated rates of 76 lb/ton of lead produced for blast furnaces and of 114 lb/ton for reverberatory furnaces* are low in comparison with emission rates from primary production of metals, they are more than twice the rates of regenerative furnaces used in manufacturing fiber glass and compare with the

*These values represent adjustments of the EPA estimates so as to reflect pounds per ton of lead product (assuming 70 percent recovery) instead of per ton of metal charged.

uncontrolled emission rates of sulfuric acid plants. Comparative costs for controls in some selected industries are considered in a later section.

Currently, no NSPS for SO_2 from secondary lead smelters are in effect. A reverberatory furnace of 50 tons/day (2.08 tons/hr) would emit about 2.85 tons of SO_2 each day and a blast furnace of the same capacity about 1.9 tons. Assuming an equal mix between blast and reverberatory furnace production, the total secondary lead production in 1975 of 658,500 tons would have resulted in about 31,000 tons of SO_2. This is about one-tenth of 1 percent of the total SO_2 emissions from stationary sources (which comprised 98 percent of the national emissions) in 1972 and the same percentage of 1975 emissions as estimated from modeling techniques by the Argonne National Laboratory (Habegger et al., 1976). This study has further estimated that by 1985 SO_2 emissions from secondary lead reverberatory furnaces will amount to about 29,000 tons. This estimate may be compared with estimates similarly derived from other source categories as shown in Table 6-1. Overall, this study has ranked lead reverberatory furnaces as fifteenth out of approximately 30 source categories on a priority basis for consideration of controls by EPA.

A wide range of SO_2 concentrations from secondary lead smelters depends not only on the amount of sulfur in the charge but also on production rates and flow rates of exit gas. These ranges are shown in Figure 6-2. A 50 ton/day blast furnace with a flow rate of

TABLE 6-1

ESTIMATED TOTAL SO_2 EMISSION
IN 1985 FROM SELECTED SOURCE CATEGORIES

Category[a]	Thousands of tons/yr 1985
Boilers (>250 x 10^6 Btu/lb)	8352
Smaller boilers	4445
Portland cement	335
Petroleum refinery (fluid catalytic cracking unit)	259
Wood pulping	164
Stationary gas turbines	125
Incinerators	63
Iron and steel	54
Glass (soda lime glass)	36
Secondary lead, (reverberatory furnace)	29
Sulfuric acid	23

[a]Primary metal production is not included; greatly reduced emissions are anticipated under existing NSPS.

Source: Habegger et al., 1976.

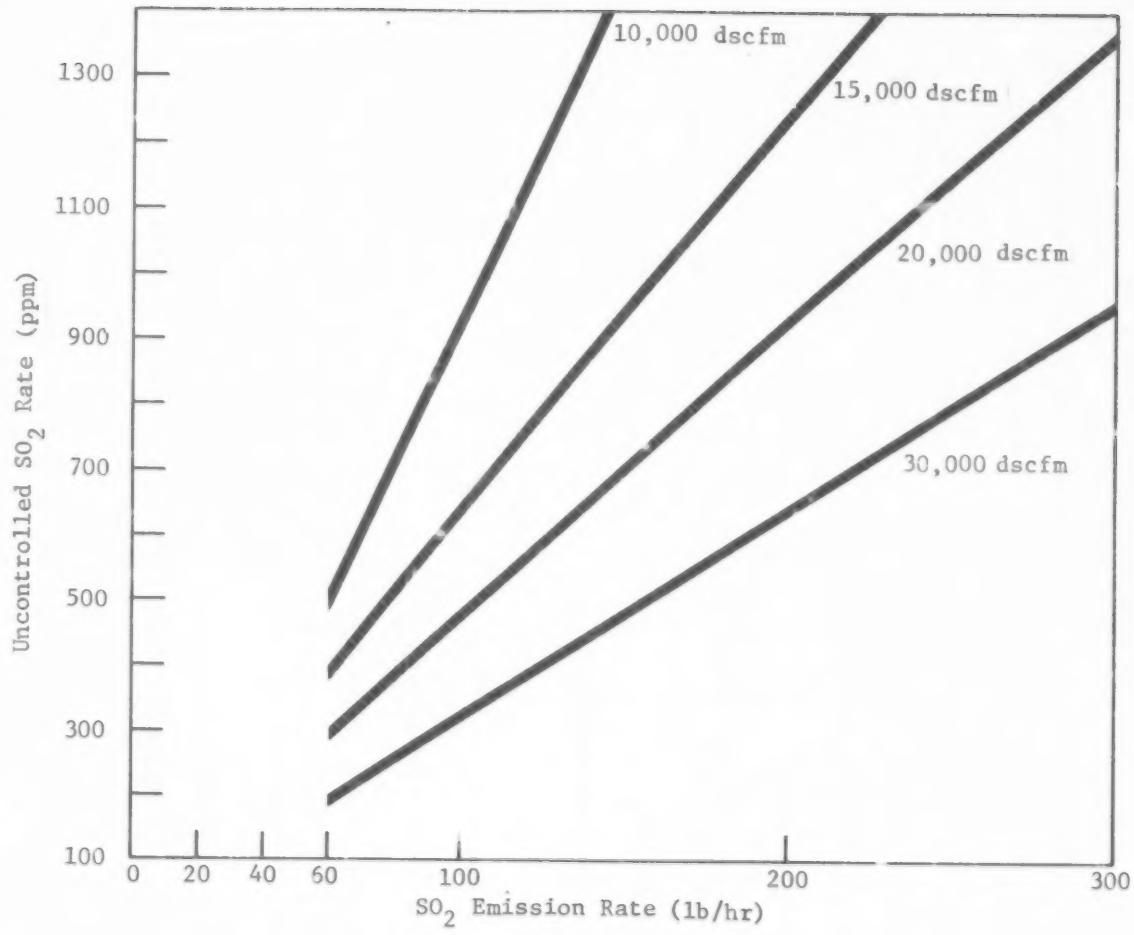


FIGURE 6-2
UNCONTROLLED SO_2 EMISSIONS

15,000 dscfm emitting SO_2 at a rate of 158 lb/hr would provide an uncontrolled concentration of about 987 ppm on a dry basis. For a reverberatory furnace of the same capacity, the uncontrolled concentration would be more than 1400 ppm. These concentrations would be reduced for higher flow rates as seen in the figure. Much variation is also shown in the limited test results available. In eight tests conducted on secondary lead smelters equipped with baghouses and/or venturi scrubbers the SO_2 concentrations ranged from less than 0.1 ppm to over 2000 ppm (EPA, 1973).

6.4.2 Resulting SO_2 Concentrations

An important consideration in regard to SO_2 emissions from secondary lead smelters is the concentration that can be expected to result, particularly at ground level. Results of calculations made on the basis of hourly SO_2 emissions are plotted in Figure 6-3. This figure plots the maximum ground-level concentration of SO_2 on the horizontal axis for selected wind speeds and emission rates as plotted on the vertical axis. Separate graphs are plotted for different meteorological conditions (A, B and D) which are conventionally distinguished. Effective stack heights (in meters) of the discharge are indicated on each graph. The computations in Figure 6-3 were based on the "Workbook of Atmospheric Dispersion Estimates" (Turner, 1969). For convenience, the output of SO_2 per hour is shown in pounds, but the downwind maximum ground-level concentration (3-hr average) is shown in micrograms per cubic meter. The secondary

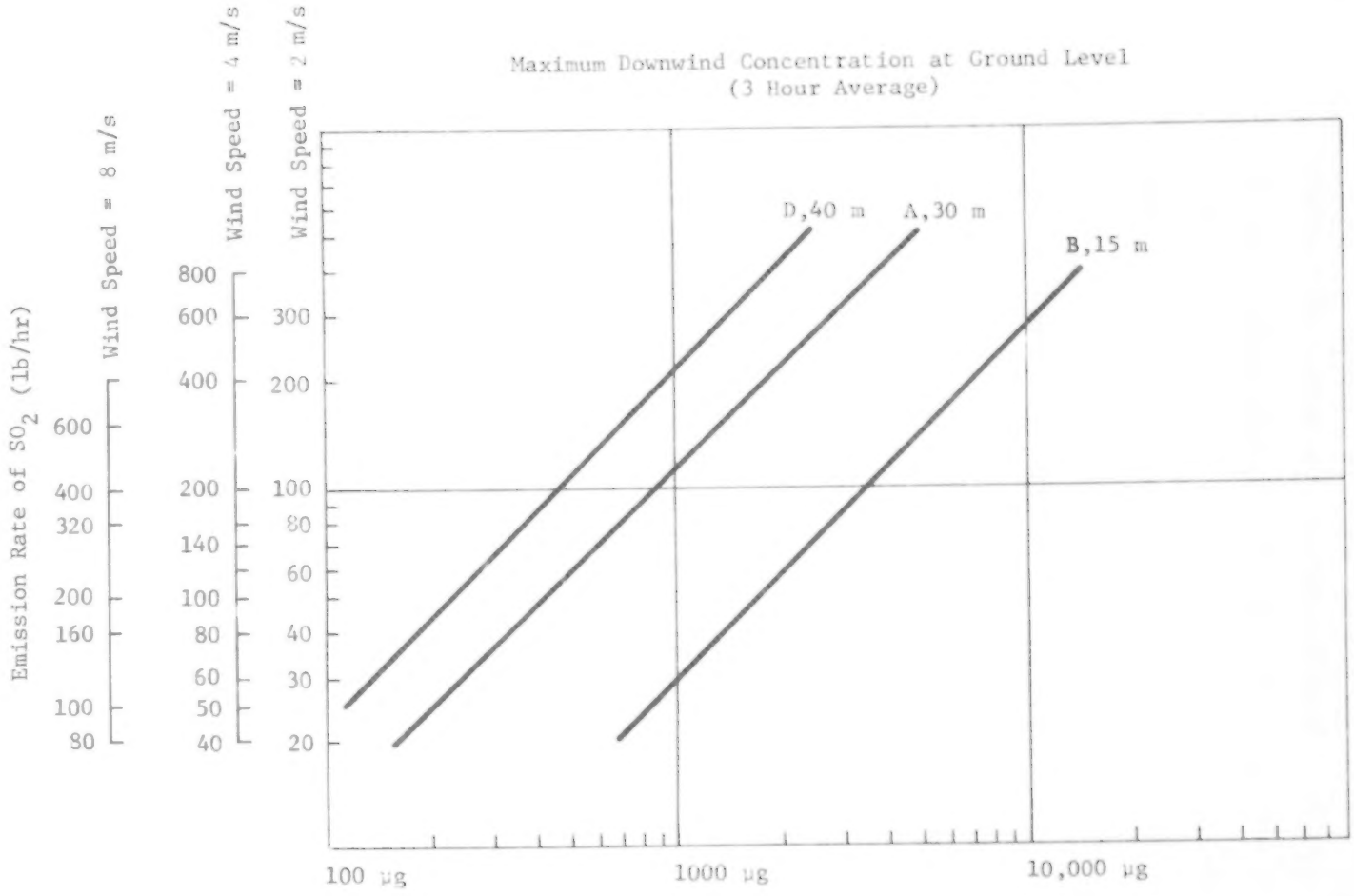


FIGURE 6-3
MAXIMUM SO_2 CONCENTRATIONS AS A FUNCTION OF EMISSIONS

level of 1200 $\mu g/m^3$ for a 3-hr average has been set as a value not to be exceeded more than once per year.

It can be seen from Figure 6-3 that a downwind concentration resulting from an emission rate of 100 lb/hr would exceed 1000 $\mu g/m^3$ only for relatively unfavorable meteorologic conditions and a relatively low effective stack height (e.g., Condition A and wind speed of no more than 2 m/s or about 4 knots maximum at a stack height of 30 m). Average height of stacks discharging from a secondary lead smelter is about 150 ft or 40 m (EPA, 1973). The effective height is somewhat greater, depending on the furnaces. For a relatively neutral set of conditions as represented by Condition D with wind speed of only 2 m/s, a furnace emitting 200 lb of SO_2/hr would not produce a maximum downwind concentration (on a 3-hr basis) of as much as 1000 $\mu g/m^3$.

6.4.3 Control Technology

6.4.3.1 Methods. Available techniques for removing SO_2 from gas exiting a secondary lead furnace consist essentially of contacting the gas with liquid containing an alkaline reagent in the form of a slurry or in solution as a clear liquor. Through chemical reaction the sulfur compounds in the gas are precipitated as sulfites or sulfates in sludge. In most processes this sludge is a waste that must be discarded. However, in regenerative processes, the sorbent is recycled to provide for recovery of marketable sulfur products. In control of SO_2 from the primary metals industry, the smelting of

lead, copper or other ores is often combined with a plant in which sulfur compounds from a regenerative control process are used to produce sulfuric acid.

The process of SO_2 removal is often referred to as flue gas desulfurization. A number of techniques are commercially available or in pilot plant operation. Much of the developmental work and many of the applications are for desulfurization of gas from boilers fired by fossil fuels. Lime and limestone are among the most commonly used reagents, but other chemical compounds such as magnesium oxide or ammonia may be used. The so-called double alkali or soda lime process employs a combination of sodium carbonate and lime or limestone.

Scrubbing equipment may involve towers or columns packed with absorbent material over which the gas to be cleaned and the scrubbing liquid pass, or in which the gas is dispersed through liquid in a series of trays or plates. Spray towers may also be used, with the liquid absorbent sprayed through nozzles. Venturi scrubbers are employed to remove both particulate matter and SO_2 from the gas, often in combination with some device such as a spray tower or after absorber, or the gas may circulate in two or more stages within the scrubber with additional reagent being added at each stage. In a broad sense, a system for scrubbing SO_2 from furnace gas may be thought of as an extension of the venturi devices and similar wet collectors employed by secondary lead smelters for particulate control. A single-stage venturi scrubber, such as commonly used in

lead furnaces to remove particulates, in which lime or limestone is employed as the slurry, can be counted on in application to utility boilers to remove about 40 to 50 percent of the SO_2 (Bechtel, 1978). Typically, two or more stages are necessary to meet SO_2 emission standards for fossil-fuel fired boilers. Tests of a prototype double alkali system employing a combined venturi/absorber configuration reportedly produced removal efficiencies greater than 95 percent when the bled liquor pH exceeded 5.2 and achieved efficiencies above 98 percent when pH of the venturi liquor was raised above 6.0 (PEDCo, 1977b).

A few remarkably low SO_2 emission rates have been reported from tests of secondary lead furnaces controlled by scrubbers denoted only as venturi (i.e., without stipulation of the number of stages or the characteristics of the chemical reagent). EPA (1977) has noted that a scrubber for particulates provides an advantage in that it may be designed for SO_2 reduction. It is not considered, however, that a scrubber designed for particulate removal could regularly meet any NSPS for control of SO_2 emissions from lead smelters. While some improvement in efficiency of SO_2 removal has been suggested for single-stage venturi scrubbers through adjustment in operating conditions (e.g., addition of magnesium oxide to a lime/limestone slurry to improve its desulfurization properties), further analysis of control requirements and their costs is based on assumption of a scrubber specifically designed for SO_2 control. Such a device might be

added to a system for removing particulates or it might be a subsystem controlling both SO_2 and particulates.

6.4.3.2 Cost Estimates. A scrubber for SO_2 removal can be very costly as an add-on to a baghouse. One reported test involved a secondary smelter in which a scrubber, representing an investment of about $700,000, reduced SO_2 output from about 1800 to 140 ppm (about 90 percent control) (Los Angeles County, 1978). On this basis a separate scrubber and baghouse for discrete control of SO_2 and particulates would approximately double capital costs. The general procedure, however, would be to install a special system designed for simultaneous removal of both pollutants. Several firms supplying control equipment were contacted for cost estimates. Secondary lead smelters do not regularly use scrubbers for reduction of SO_2 emissions, at least not to the same degree as controls for trapping particulates (EPA, 1978). Industrial representatives were reluctant to supply cost estimates applicable to lead furnaces. When experience of the firm was in SO_2 control of fossil-fueled boilers, difficulty was expressed in using costs based on kilowatt capacity of a power plant or heat-input rate of an industrial boiler to estimate costs for secondary lead furnaces of the size modeled by EPA (1977) at 50 tons/day with exit rates of furnace gas in the range of 32,000 to 33,500 ACFM. However, a few spokesmen supplied data varying in amounts and in level of detail which indicate industrial capability to provide a combined unit for simultaneous removal of both particulates and SO_2.

Direct comparison between costs of combined systems and those used only for particulate removal is difficult because of varying estimates which may not include all of the same items. Estimates must be general because they apply to hypothetical plants with unspecified design parameters; thus, only an approximation or a range of values can be indicated. Within these limitations, evidence shows that the capitalization costs of a combined system are about 10 to 20 percent higher than those of a scrubber installed to control only particulates.

Based on manufacturer estimates, capital costs of a combined system for a 50 ton/day secondary lead furnace fall between $500,000 and $1 million. These costs include installation, instrumentation, all materials, equipment for sludge handling, engineering, training in usage, and start-up. They are from 25 to more than 50 percent higher for blast furnaces than for reverberatory furnaces. Taking $750,000 as the midpoint of the range for a reverberatory furnace and $1 million for a blast furnace, comparison with EPA (1978) estimates for particulate controls with a venturi scrubber of $669,000 and $895,000, respectively, indicates increases of about 11 percent. This relationship correlates with the estimate of one firm (based on applications to plants generating electric power) for scrubber costs designed to remove particulates only and those for combined removal of particulates and SO_2. These cost estimates are for installation made at the time of plant construction.

These estimates may be compared with those in a recent study of costs of controlling SO_2 and particulates in coal-fired boilers used by power plants (PEDCo, 1978). Computerized modeling techniques were used to calculate costs of several SO_2 control systems (with particulate removal) for power plants of different capacity under scenarios reflecting the type of coal burned and pecentage of SO_2 removal from flue gas. Although the data were developed specifically for coal-fired utility boilers, from the parametric assumptions regarding flow rates and SO_2 output, it is possible to draw analogies with control of secondary lead smelters.

In particular, it may be of interest to compare the inferences of this study as to the increase in capitalization costs resulting specifically from components designed to reduce SO_2. It was found that the study of costs for power plants produced somewhat higher estimates than the above-cited figures, both for capitalization requirements and increases due to SO_2 control. Assuming that costing of heat exchangers, fans and motors, and valves and ducting reflected requirements for particulate removal as well as SO_2 reduction, equipment specific to SO_2 control was calculated to increase direct costs (all installed equipment, plus sludge pond) by over 55 percent. Total cost increases ascribed to SO_2 removal were from about one-fourth to one-third, depending upon what items of indirect cost necessary to a power plant are also judged applicable for secondary lead furnaces.

Direct costs were estimated to be about $1.1 million. Total costs ranged from about $1.4 to under $2 million, again depending on what indirect costs used by the model were included. These estimates were obtained by equating a 50 ton/day secondary lead furnace burning 0.8 percent sulfur coal to a 9-MW power plant, on the basis of flow rate of exit gas and rate of SO_2 output. Costs in dollars per kilowatt as calculated in the model methodology for the scenario of 90 percent SO_2 reduction by use of lime scrubbing were then applied to arrive at rough approximations applicable to the secondary lead smelter.

Annual operating and maintenance costs for scrubbers have been estimated to range from 8 to 18 percent of total capital investment with 13 percent as an average figure, although very high costs of up to 40 percent are noted (Kinkley and Neveril, 1976). In modeling of costs for scrubbing and absorption systems to remove particulates as well as SO_2 from flue gas emitted by coal-fired boilers used in generating power, operating and maintenance (O&M) costs were estimated to run 16 to 18 percent of capitalization costs (PEDCo, 1978). The range of 13 to 16 percent is consistent with results reported in operation of one manufacturer's equipment with particulate and SO_2 control of flue gas (Ferb and Stevens, 1978; Research-Cottrell, Inc., 1978). Fixed annualized costs representing about 20 percent of the total capitalization requirements have been used by EPA (1977).

Thus, 35 percent of the total capital investment representing the sum of the O&M and fixed costs, may be used as a factor to estimate total annualized costs of a combined system for venturi scrubbers controlling particulates only. On this basis, costs for a blast furnace would be about $350,000/yr and $262,500 for a reverberatory furnace. It is not clear whether the same credit would apply for recycled lead from the sludge of a venturi scrubber designed to remove particulates only as would apply to that produced by the combined system. If the value of recycled lead is taken at $75,000/yr, annual costs would be reduced to $275,000 for a blast furnace and $187,500 for a reverberatory furnace. Based on the assumption made in regard to recycling, at an average output of 6875 tons, price per ton of lead product would be increased by an amount between $27.27 and $38.18 for a reverberatory furnace and between $40 and $50.90 for a blast furnace. These estimates compare with increases in cost of $22 and $33 per ton resulting from use of a venturi scrubber to control particulates alone.

6.4.3.3 Estimated Costs per Ton Captured. An important consideration in regard to the possibility of NSPS for control of SO_2 emissions from secondary lead furnaces is the cost per ton of SO_2 captured. Such costs may differ by more than an order of magnitude when compared with other industries; for example, about $40 to $60/ton of SO_2 captured in H_2SO_4 plants and from around $500 to nearly $1500 for electric generating utilities, depending on the type of

coal burned. It is estimated that in H_2SO_4 plants reduction of the uncontrolled rate of 26 to 56 lb of SO_2 per ton of product to the maximum permissible level of 4 lb/ton is achieved at a cost (based on a 1970 estimate) of $1.05 per ton of H_2SO_4 produced (Chemical Construction Corporation, 1970). While this cost may have advanced substantially since then, even if the increase significantly exceeded the overall rate of inflation, the per ton cost would still be only a small fraction of the estimates for removing SO_2 from flue gas of coal-fixed utilities (EPA, 1978d).

In the secondary lead industry the incremental annualized costs for combined SO_2 and particulate control over those for particulate removal alone as primarily calculated are about $35,500 and $49,000, respectively, for a 50-ton-day reverberating and blast furnace (Table 6-2). On the basis of average uncontrolled emission rates and annual production, each plant may be estimated to release at present 393 and 260 tons of SO_2 per year, respectively. With 80 percent reduction, the costs per ton of SO_2 captured would be $113 and $236, respectively.

6.4.3.4 Level of Control. Reduction of SO_2 in the gas stream by well over 80 percent is commonly reported in the operation of lime-based scrubber systems used by coal-fired power plants. However, in the present context these results must be considered with some caution until more comprehensive data are available from long-term operation. The magnesium oxide and double alkali systems are designed for removal of 90 percent or more SO_2 from utility plants

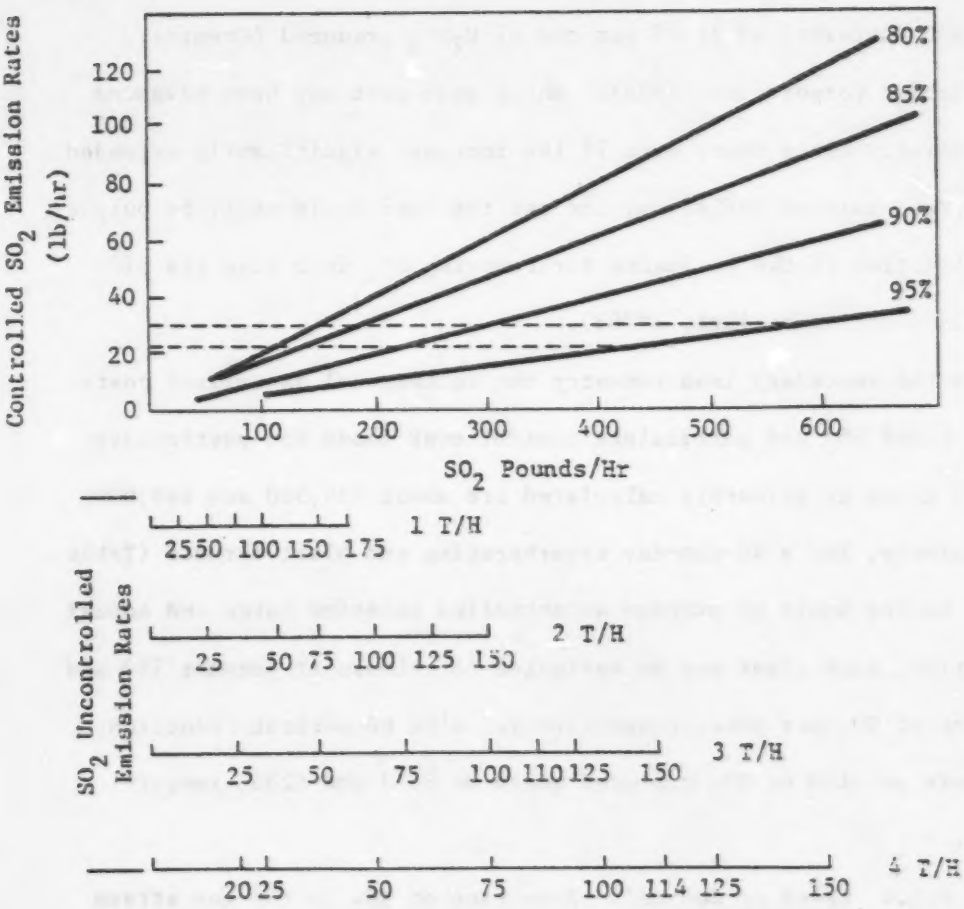


FIGURE 6-4
SO_2 EMISSIONS AT SELECTED CONTROL LEVELS

TABLE 6-2

ESTIMATED COSTS OF SO_2 CONTROL
PER TON CAPTURED

Parameter	Reverberatory Furnace (dollars)	Blast Furnace (dollars)
Annualized costs, combined particulate and SO_2 control	187,000	275,000
Annualized costs, particulate[a] removal alone, with venturi scrubbers (Table 4-6)	152,000	226,000
Incremental costs, SO_2 removal	35,500	49,000
Average SO_2 output, lb/ton lead product[b]	114.29	75.71
Average annual production, tons/plant (1975)[c]	6,875	6,875
Average uncontrolled SO_2 emissions, tons/year	393	260
Tons captured at 80% reduction	314	208
Average cost/ton captured	113	236

[a]As discussed in Section 6.4.3.2.

[b]Adjustment of AP-42 estimates on basis that 70% metal charged is recovered as lead product.

[c]Bureau of Mines (1976).

and have tested at this level in pilot or prototype operation. Results in this range have been reported among others from the GM Parma system, the Mystic Station Unit No. 6 at Everett, Massachusetts, the Firestone-Potts system, and the Gulf-Scholz prototype system (PEDCo, 1977; EPA, 1978c). In support of the Background Information Document for proposed revision of NSPS applicable to steam-generation of electric power, cost calculations for combined removal of SO_2 and particulates were made for scenarios with 80 and 90 percent reduction of SO_2 (PEDCo, 1978). One manufacturer producing combined units for removal of both SO_2 and particulates supplied a brochure with sample cost calculations (for a coal-burning utility boiler) on the basis of average SO_2 removal efficiency of 95 percent (Research-Cottrell, Inc., 1978).

However, these results are based on very limited operation and represent systems designed to remove SO_2 from combustion of coal or high-sulfur fuel oil. Technology transfer would be involved in applying them to the secondary lead industry and any predictions as to the success of such transfer could at this time be offered only with reservations.

The question may be raised regarding efficiency of particulate removal by such combined systems. Use of venturi scrubbers may be considered marginal with reverberatory furnaces which emit very fine particles of less than 0.4 microns and a mean size of 0.3 microns.

In the absence of specific data from tests and/or operating experience with such combined systems for secondary lead furnaces, there is some risk. An owner who purchased such a system (at a cost from 10 to 25 percent above the price of venturi controls for particulates) and then found his plant out of compliance with NSPS might face a severe penalty. If forced to obtain a fabric filter system in addition, the owner would incur costs essentially double what they would have been for control of particulates alone. It may be noted, however, that some combined equipment is designed for such eventualities, by enabling improved collection efficiencies to be achieved through higher fan horsepower to increase the pressure drop (Research-Cottrell, Inc., 1978).

6.4.4 Potential Impacts of SO_2 NSPS

6.4.4.1 Environmental Effects. Environmentally, the chief potential impact of promulgating NSPS for SO_2 emissions from secondary lead smelters will be the reduction of sulfur oxides discharged. There will be some increase in energy requirements and fuel consumption for control systems and an undetermined additional solid waste disposal.

Quantitatively, the estimates of potential environmental impacts depend on the production rate of plants subject to NSPS. Since this cannot be determined for a future time or even precisely estimated from available data, it is necessary to indicate the probable effects as a range of values. As shown in Table 6-3, the uncontrolled emissions of SO_2 per year from a single plant are estimated to range

TABLE 6-3

ESTIMATED REDUCTIONS IN TOTAL ANNUAL
SO_2 EMISSIONS FROM FUTURE NSPS

Average rate uncontrolled SO_2 emissions, lb/ton of product[a]	95		
Estimated annual production of lead per plant, tons	6,000	13,000	18,000
Estimated uncontrolled annual SO_2 emitted per plant, tons	285	618	855
Tons captured, per 10% reduction	28.5	61.8	85.5
Tons captured, 80% reduction	228	494	684
Tons captured, 90% reduction	257	556	770

[a]Rate obtained as the average of separate estimates for blast and reverberatory furnaces (see Table 6-2).

from under 300 to over 850 tons, depending on assumptions made as to the plant's annual production. Tons of SO_2 removal per plant at a level of 80 percent reduction accordingly vary from 228 to 684 per year. With an average of from three to four additional plants subject to NSPS each year, the expected effect would then be to reduce SO_2 emissions by an additional annual amount of between about 700 and 2,700 tons. At a level of 90 percent captive, an additional amount of SO_2 between about 770 and 3,000 tons would be removed each year.

Increased requirements for energy and fuel may be estimated from the substantially higher pressure drop required in scrubber systems for jointly controlling SO_2 and particulate emissions over the very modest requirements for fabric filters. The increased pressure drop may be conservatively estimated at 50 to 80 inches water gauge with corresponding horsepower increases of between 200 and 300. To produce the annual tonnages listed in Table 6-3, plants of about 50,100 and 150 tons/day may be estimated to operate about 2800 hr/yr. On this basis, an additional 400 to 600 kWh of energy would be required each year with a Btu equivalence in the range of 4.2 to 6.4 x 10^9. The fuel requirements in terms of barrels of oil average about 1000 barrels/plant anually. This figure represents an infinitesimal increment to total U.S. oil consumption of over 6.4 billion barrels in 1976 and is a very small fraction of 1 percent of even the average daily import of more than 7 million barrels in the same year (Bureau of Mines, 1976).

The question of increased disposal of solid waste from NSPS for SO_2 from secondary lead smelters is problematical. EPA (1973) originally estimated that sludge collected from scrubbers could be dried and the lead recycled. Data are not available as to how much such recycling is practiced in the secondary lead industry.

Recycling of scrubber sludge after drying may or may not be feasible, depending particularly on what reactive agents are used in the scrubber. Problems with the scale and reduced throughput may constrain recycling. Most of the dust trapped by fabric filter systems is reportedly recycled until the dust becomes too contaminated with lead chloride. At that time, part of the dust is leached or landfilled (EPA, 1978b). The study of priorities for development of NSPS for additional stationary sources (Habegger et al., 1976) regarded control of SO_2 from secondary lead furnances as involving a trade-off between reduction of atmospheric emissions and aggravation of the solid waste problem.

In the absence of the necessary specific quantitative data, it can only be concluded that some fraction of the total amount of sludge trapped would require disposal as solid wastes. Since it is also not known what fraction of particulate dust trapped by fabric filter systems is recycled, quantitative comparison on a dry-weight basis of the solid waste disposal requirements with and without SO_2 control is not possible. It is likely that the amount recycled from a baghouse would be substantially higher than that regenerated by drying of sludge. One factor militating against recycling of sludge dried from

a scrubber that removes SO_2 is the presence of a high concentration of sulfur.

6.4.4.2 Potential Economic Effects. The immediate economic effect of any NSPS for reduction of SO_2 would be in terms of the increased cost to secondary lead producers. As noted previously, the data are incomplete. Compared with the expenses of providing scrubbing for particulates only, it appears that an increment of 10 to 20 percent is involved, although increases of up to one-third cannot be ruled out, based on the modeling methodology employed for coal-fired utility boilers (PEDCo, 1978). In other words, a plant owner who faces an increase in annualized costs of $33/ton of product from a blast furnace for venturi control of particulates might find that removal of SO_2 also requires his cost to be $43/ton (30 percent higher). This difference of $10/ton represents about 2 percent of the estimated 1978 price of a ton of lead ($534) escalating the 1976 average value to 1978 prices.* Higher percentages would result from different assumptions about the costs for scrubber systems with and without SO_2 reduction specifically built in, but preliminary indications are that the additional cost for SO_2 control would be in the range of 1 to 5 percent of the average price of a ton of lead.

The increased costs may place an inequitable burden on the small operator. The scale factor for combined scrubber systems is unknown;

*The price of lead has increased over the years but at a rate less than the general inflation rate and less than costs of equipment and other materials as pointed out in discussing the fact that lead prices have declined in terms of constant dollars.

however, in terms of cost per ton product, it is certain to favor the large plant.

Besides the effect on the small operator, there are other important questions relating to the economic impacts of NSPS for controlling SO_2 from secondary lead smelters. One of these is the extent to which additional costs can be passed on to the consumer. Limited evidence suggests that no significant shift in demand would occur because of cost increases for lead that are less than 10 percent (in constant dollars).

It appears that demand for lead will be more strongly influenced by technologic developments and environmental restrictions that change usage patterns. Examples include attrition of the tetraethyl lead market for gasoline and the substitution of other bases ranging from water to titanium and zinc for interior paints. Unquantified results of studies show the demand for lead as largely insensitive to price. The fact that there is little correlation between price increase and rise in demand from year to year is consistent with the hypothesis that demand for lead is price inelastic (Charles River Associates, 1971; American Metal Market, 1972).

Perhaps the most significant area of concern relates to the competitive effects of controls for SO_2. The competitive position of secondary lead vis-a-vis the primary product has been noted, as well as the increasing interchangeability of demand for lead from recycled and virgin material. At the time of proposing NSPS for secondary lead smelters, EPA (1973) noted the relatively higher costs of pollution

controls required of the primary industry and reasoned that the NSPS would not weaken the competitive position of secondary material in the total lead market. This conclusion is not likely to be affected by increased pollution control costs if they were on the order of no more than 5 percent to secondary lead smelters.

Within the secondary lead industry, however, the competitive effects are likely to be more significant. The trend to increasing centralization of the secondary lead industry has been noted. Evidence indicates that a larger share of the market is going to large companies and some small companies are being forced out. It is problematic how much this existing trend might be accelerated by increases on the order of 1 to 5 percent in production costs resulting from NSPS for SO_2. It is true that this range more than covers the net income margin of small companies. With a few companies dominating the market, large producers might well absorb some or all of the additional cost with the result that prices would be held down; lead would sell at a price that did not fully cover increased expenses for many of the approximately 20 small operators. Small firms would then be operating at a deficit and in time would be forced out.

It is also true that new plants subject to NSPS controls for SO_2 would be placed at a disadvantage vis-a-vis existing plants. To analyze how the resulting cost differential would operate requires more detailed data concerning control costs and the overall capital and annual expenses of new and existing plants, production rates, the

financial position of the parent companies and other factors that affect position in the secondary lead market. These issues indicate that in addition to a study of technological feasibility, a comprehensive economic analysis is required in any consideration of possible NSPS for this pollutant.

7.0 CONCLUSIONS

7.1 Retention of Current NSPS

Any change in current NSPS for secondary lead smelters would be unwarranted at this time. These standards are for particulates (0.022 gr/dscf) and for opacity (<20 percent for blast and reverberatory furnaces, <10 percent for pot furnaces). When the standards were set in 1974, they were based on control technology available at the time. There are no indications that the state of this technology has changed since then. Best systems of control consisted of baghouses (fabric filters) and venturi scrubbers, and today these still represent the best technology for particulate removal. Efficiencies of collection systems required to meet current NSPS for particulates are in line with efficiencies reported elsewhere, with manufacturer estimates of performance, and with the extremely limited test data available. The standards are not too stringent, as evidenced by the fact that they are being met and by the absence of reported difficulties in achieving compliance.

In regard to more stringent standards, there is no substantial evidence available by which they would be justified. The sample of tests in which lower emission rates were achieved is entirely inadequate as a basis for any valid inferences about the general feasibility of meeting stricter standards. A literature search indicates no more stringent levels in existence locally as a basis for comparison. The very small (submicron) size particulates from reverberatory

furnaces, against which the efficiency of high-energy venturi scrubbers and to a lesser degree of baghouses declines as compared with larger particles, raises technical questions about how adequate existing control systems would be in general to meet significantly stricter standards.

Even if lower emission rates could be shown as entirely feasible, potential environmental gains would be marginal. Lowering the allowable particulate emissions to half those now permitted would capture about 1 additional ton/year from a 50-ton/day plant (Table 4-8). Total reductions from plants newly subject to NSPS in any one year would not amount to 5 tons.

From the scarcity of available test data, it is concluded that there is a strong need to assemble over the immediate future all obtainable results as they become available. Analysis of an adequate data base would be essential in determining whether technologic improvements in control systems have occurred that are adequate to support more stringent standards at a future time. Detailed data are needed from tests by which to correlate performance of different control systems as a function of the type of material charged to the furnace, particulate size distribution, inlet loading to the collector, parameters of the system (e.g., air-to-cloth ratios for fabric filters, pressure drop and ratio of water to air flow for venturi scrubbers), maintenance and other operating features of the smelter. The relationship of percentage of opacity in the stack discharge from

a control system to particulate grain loadings would be of interest. Physical considerations, as well as the analogy of results in other industries, suggest that a percentage of opacity lower than 20 or even 10 percent is associated with meeting particulate standards; but quantititative data are lacking.

7.2 No Specific NSPS for Lead Emissions

It is concluded that no need exists for specific NSPS for lead emissions from secondary smelters. The consensus of available evidence strongly indicates that the current standards for particulates promote installation of the best systems of control technology for lead. The lead content of emissions vented by an adequately controlled plant (i.e., one which meets or surpasses NSPS for particulates) is no higher than 23 percent. The resulting content of lead in the air at ground level, even at points of maximum downwind concentration, would not approach the critical point of 2 $\mu g/m^3$ on a 24-hour average basis. Specific NSPS for lead emissions would be essentially redundant to current standards for particulates. Considerable procedural involvement and expense to officials, both within the government and outside, would be required with no commensurate environmental gain.

It is also concluded that information regarding the rate and form of lead emissions from secondary lead furnaces is somewhat incomplete, in particular in regard to the disposition of lead-bearing particles of different sizes. Tests under both laboratory and operating field

conditions would be useful for comparing the distribution of lead-bearing particles by size in baghouse catch and in the material vented from the fabric filter control system. Most of the available material indicates that particulate control systems trap at least as high a percentage of lead particles as that present in the inlet loading; but the data are fragmentary, represent diverse sources, and are inconsistent with preliminary reports of a more recent test. Definitive resolution of any question remaining requires a comprehensive material balance on lead emissions from furnace to collector outlet.

A significant conclusion in regard to the effect of particulate controls is that the rate of lead emissions may have been reduced about 2 tons/year/plant. The cumulative reduction in total emissions due to NSPS is estimated to be about 270 tons since 1974.

7.3 Study of Fugitive Emissions

It is concluded that inadequate information is available on the extent of fugitive emissions of lead-bearing particles from secondary lead smelters. It is not possible to assess how serious the impact of such emissions may be in the vicinity of the plants or to determine whether regulatory standards applying specifically to such emissions are warranted. For example, it has been suggested that control of fugitive emissions from lead smelters may be necessary to meet NAAQS for lead (EPA, 1978b). In addition to this question and the determination of typical emission rates from fugitive sources, investigation is warranted into the relative contribution of process- and

site-related sources to lead particulate matter in the atmosphere and soil around secondary smelters, as discussed in Chapter 6.

It is also concluded that applicable technologies and procedures for control of fugitive emissions should be investigated with the specific objective of determining their efficiency quantitatively. These include techniques such as flash agglomeration and improvements and/or additions to hooding and venting to prevent escape of particulate matter during smelting. Among procedures warranting investigation are the effect of maintenance practices, dust storage in open piles, and dust management around the smelter. It is concluded that such investigations would provide information necessary not only to determine whether fugitive emissions should be specifically regulated and if so at what level, but also in deciding what form a standard should take (e.g., in terms of maximum allowable emissions or of prescribed standards of equipment and procedures).

7.4 Investigation of NSPS for SO_2 Emissions

It is concluded that NSPS to control SO_2 emissions from secondary lead smelters appear technologically feasible at this time but demonstration is lacking. The total output of SO_2 is not high from the industry and more especially from plants that would become newly subject to NSPS in any one year. However, the uncontrolled emission rate in pounds per ton of lead product appears significant in comparison with that from controlled sources. The average or typical rate of 80 lb/ton of metal charged from a reverberatory furnace is 20 times

the permissible rate per ton of product from sulfuric acid plants (40 CFR 60). Although the average rate (53 lb/ton of metal charged) is lower for blast furnaces, the estimated range extends up to more than 150 lb/ton. Control methods are now technologically feasible to reduce SO_2 emissions by about 80 to 90 percent over the rate of emissions from the furnace stack. However, it is not concluded that NSPS for SO_2 are warranted for secondary lead smelters at this time.

An important consideration in regard to possible NSPS for SO_2 is potential cost to the secondary lead industry of additional controls. Information on their cost and effects is inadequate to support any conclusions. Best available evidence indicates that reduction of SO_2 pollution and simultaneous control of particulates could be achieved at capitalization costs in the probable range of 10 to 20 percent over the cost of a venturi scrubber system to control particulates. This increment would not exceed 5 percent of the average price of a ton of lead product and more likely is within 2 to 3 percent. It also appears that this additional expense would have little effect on the marketability of secondary lead. Demand for lead from both primary and secondary sources seems to be relatively inelastic.

It is concluded that some danger to small firms operating lead smelters would result from the promulgation of NSPS for SO_2. It is also deemed probable that new smelters required to undergo the expense of providing SO_2 controls would face a competitive disadvantage

relative to existing plants, the extent of which cannot be determined from current information. In view of the limited manufacturer's data obtainable and the generality of the estimates provided, further investigation of costs is necessary. In particular, consideration should be given to effects on small companies and to the competitive position of new plants vis-a-vis existing ones.

Because the uncontrolled rate of SO_2 emissions from secondary lead smelters appears significant and because transfer of control technology appears promising, it is concluded that the question of NSPS for SO_2 warrants detailed investigation with emphasis on costs and affordability.

8.0 RECOMMENDATIONS

8.1 Current NSPS for Particulates and Opacity

For the present, NSPS should be retained at the current level of 0.022 gr/dscf for particulates and <20 percent for opacity (<10 percent for pot furnaces).

Prior to the next review, comprehensive data should be gathered from detailed tests and analyzed to determine performance of control devices as a function of both system parameters and operating characteristics of the smelter, as indicated in Section 7.1.

8.2 Comprehensive Data on Lead Content of Emissions

While no explicit NSPS regarding lead emissions from secondary smelters are recommended at this time, it is recommended that comprehensive data be collected on the disposition of lead-bearing particles emitted from furnaces. As discussed in Section 7.2, tests under laboratory and field conditions are recommended with sufficiently detailed results to construct materials balance of the lead emissions by blast and reverberatory furnaces and to determine distribution of lead particles by size in the inlet loading to and output from the control system. It is recommended that tests be conducted to define the emission rate of lead from control systems.

8.3 Fugitive Emissions

An investigation should be made of the extent to which fugitive emissions represent a problem at secondary lead smelters controlled under NSPS. Research and development should also be conducted into

the most effective technologies and procedures for controlling such emissions from both process- and site-related activities at secondary lead smelters. These investigations should be directed toward developing data by which to determine whether a specific NSPS to control fugitive emissions at secondary level plants is warranted and what form the regulation should take.

8.4 NSPS for SO_2 Emissions

It is recommended that action be taken to investigate the question of NSPS for SO_2 emissions from secondary lead smelters. Further recommendations relating to specific investigations are:

- costs, both capitalization and annualized (including operating and maintenance expenses), of such systems with particular reference to costs that might be incurred by relatively small smelters (less than 50-tons/day capacity) if such new plants are brought on-line or existing ones of this size are modified or reconstructed.
- economic impacts of a regulatory standard for SO_2.

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